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PROGRESS REPORT

Contract No. Nonr 875(00)
Annex XII
August 1, 1954

Prepared for

The Office of Naval Research
Washington 25, D. C.

Report No. 1327

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This document has been reviewed in accordance with OPNAVINST 5510.17, paragraph 5. The security classification assigned to it is correct.

Date: 11/2/54 K. E. Wright
By direction of
Chief of Naval Research (Code 461)

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TABLE OF CONTENTS

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PROGRESS REPORT

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SUMMARY

When the preceding progress report was written for the period leading up to 1 June 1954, the following items had been accomplished.

1. The theory of the super-pressure balloon, upon which the work under this project is based, had been formulated. The problems of super-heat, and the special properties of the onion-shaped balloon, had been discussed with the balloon group at the University of Minnesota during a conference on the subject of super-pressure balloons. Material requirements for strength and elastic modulus had been derived.

2. Certain materials and combinations of materials had been chosen for investigation on the basis of their properties at room temperature, and their tensile properties at low temperature had been studied experimentally with a portable cold box enclosing the jaws of the tensile tester.

3. The program for the development and testing of a super-pressure balloon to meet the required objectives had been built around four major types of balloon design.

   a. A nylon fabric cover containing a polyethylene or rubber bladder. Two balloons of this type, using polyethylene bladders had been built and flown. In both cases, the polyethylene bladder had failed before significant internal pressure had developed.

   b. An onion-shaped cylinder balloon of Saran or of polyethylene-on-Mylar. One of this type of balloon constructed of polyethylene-on-Mylar had been built and flown. The balloon had ruptured near a fitting after being subjected to only slight internal pressure.

   c. A sphere of Saran. The production of this type of balloon awaits the completion of the mobile electronic sealer which is being developed under this project.

   d. A sphere of polyethylene impregnated fiberglas. The construction of this type of balloon awaits the production of a satisfactory bond between the polyethylene and fiberglas, a problem which is being attacked by the Bebzckman Company. Seals in this balloon would be ordinary lap-type heat seals of the polyethylene. Experiments with samples of polyethylene impregnated fiberglas had shown the seals to be stronger than the fabric.

4. A measure of relative super-heat among balloon materials had been obtained by a laboratory technique using an infra-red lamp.

5. One flight on a 25 foot open appendix balloon had been made to investigate the relative upward and downward radiation during night time

During the period 1 June to 1 August, which is the period covered by the present report, the following items have been accomplished.

1. Ten 1,800 cubic foot onion-shaped balloons of Saran have been produced by Brown and Bigelow with their electronic sealing equipment. One of these was laboratory tested and four were flown. The remaining five are on the shelf awaiting new type fittings.

The polyethylene-on-Mylar material was received and six 1,800 cubic foot onion-shaped balloons were constructed of it. One of these was laboratory tested, four were flown and the remaining balloon is on the shelf for study of dimensions actually produced, seals, etc.

Modifications in the polyethylene bladder for the polyethylene-in-nylon balloon were made on two balloons which were later flown.

The design work for the mobile electronic sealer for Saran film was completed and the assembly of the first prototype is expected during the first week of August.

I. ENGINEERING STUDY

A. Special Problems of Super-Pressure Balloon Construction

The series of flights conducted at Pierre, South Dakota, during the week 7 July to 14 July, which are reported in detail under Section III-B, emphasize the fact that the construction of a super-pressure balloon presents a problem which is different qualitatively from that of constructing an open-appendix balloon. Not only must the balloon be fabricated with the greatest of care to prevent any damage to the material or to assure that the seals are perfect, but the material itself must be hole-free to an extent heretofore not required. Although the gas permeability of the films being used is well on the safe side, calculations show that, if the areas of all the holes, from flaws or from damage, when added together, would amount to a hole which exceeds 1/32 of one inch in diameter, the super-pressure balloon of the size contemplated will fail to meet the required flight performance.

All of the balloons flown from Pierre expelled their free-lift gas, after developing only a fraction of the internal pressure for which they were designed, and descended after a short time, some imes without ever reaching their theoretical ceiling. (An onion-shaped balloon may develop an internal pressure before reaching its theoretical ceiling for reasons explained on page 10 of Report no. 1312 dated 1 June 1954).

We feel confident that there are ways for manufacturing balloons which will meet the requirements as to gas tightness, and additional engineering talent has been enlisted to work on this problem. The major points of the program which they are pursuing are outlined in Section IV.

B. Special Problems in the Construction of the Onion-Shaped Balloon

The laboratory tests during which onion-shaped balloons were inflated revealed a problem involving the equal distribution of stresses around the circumference of the balloon. With the materials being used, the material thickness necessary, and the present gathering techniques, it appears that some meridional sections of material are taking greater stresses than others. This is apparent in Photographs #8125, #8131 which show quite clearly that, while some material sags between the equator and the lower fitting, other material takes a more direct line from the fitting toward the equator forming a chord connecting the outer contour of the balloon at two points. It would be expected that the material which forms the chord would be stressed more than that which billows out beyond it. Strain gages will be used to evaluate the difference in stress which is involved here.

A new fitting is being designed and a new technique for gathering the material at either end will be used in an effort to determine whether this feature is an essential part of the onion-shape or whether it is a function of the type of folding used in gathering the ends or the manner in which it is held.

The greatest care was exercised in installing the fitting to make certain that the distance from one fitting to the other along one meridian was the same for all meridians and, since the main feature of the onion-shape is an excess of material circumferentially under all conditions, some folds radiating out from the fittings must be expected. However, if the meridional stresses are to be distributed uniformly around the circumference, these folds must not be allowed to assume more than their share of the stress. Although the materials and their thicknesses,which are being used, provide a design strength which is somewhat greater than available information on super-heat indicates to be necessary, such design strengths are calculated on the assumption that the meridional stresses are uniformly distributed about the circumference. If large variations in stress are unavoidable, the onion-shaped balloon, while feasible in theory, may not prove successful with presently available materials.

By making a thorough study of all aspects of the onion-shaped balloon, we hope to answer this question conclusively.

Another feature of the onion-shaped balloon, as produced so far under this project, which may make a critical difference between the theoretical performance and the actual performance, was also revealed by the laboratory tests. In the major fold,which always develops during the inflation of an onion-shaped balloon, it was noted that the seals do not run directly from fitting to fitting; that is, they do not run in a true meridional direction, but rather they run obliquely from the fitting into the fold and out again. It was also noted that when the stresses began to develop as a result of the internal pressure, the stress lines, indicating the direction of the stress, held true to theory, being oriented vertically, that is, meridionally. Thus the condition which the onion-shaped balloon was especially designed to eliminate was actually produced; that is, the seams were subjected to transverse stresses. This condition is visible in Photograph #8133. If there is no way of eliminating these transverse stresses, the main advantage of the onion-shape is removed, and balloons which depend upon this feature, as do the polyethylene-on-Mylar balloons, which have a polyethylene seal, cannot be expected to perform in accordance with the theory.

By making a thorough study of all aspects of the onion-shape balloon, we hope to answer these questions conclusively.

C. The Radiation Problem

In a discussion with Dr. Barkley, it was decided that, if the radiation problem were to be studied thoroughly, the instrumentation itself would be a major project. With the balloon design and construction at its present state of development, it does not seem advisable to spend time on this project investigating the quantitative values of the effects of radiation upon a balloon which we have yet to prove feasible. This project will limit itself to delineation of the factors to be considered, an investigation of the spectra of the materials used, and suggestions of where other information might be obtained, or experiments that might be made, if deemed necessary.

D. Comparison of Balloon Weights Sphere to Onion

The polarized stress, which theory tells us we should obtain in an onion-shaped balloon, is bought at quite an increase in balloon weight. Calculations show that for a given material and material thickness, and a given volume, the weight of an onion-balloon exclusive of fittings will be 1.78 times the weight of a spherical balloon with the same specifications.

II. BALLOON CONSTRUCTION

The dimensions of the onion-shaped balloons which have been made, both with Saran and with polyethylene-on-Mylar, are as follows:

Length between fittings = 23 feet
Circumference = 663 to 683 inches.

In order to protect the material in the onion-shaped balloons from the bolt which protrudes through the fitting into the balloon, a 2 to 3 inch length of 7/8 inch I.D. tygon tubing was fastened to the inside wedge, thus surrounding the bolt as it came through the wedge and preventing contact between its edges and the material when the balloon was folded.

A. Saran

The cylinders produced by Brown and Bigelow, using their straight bar electronic sealer on Saran film and from which we made the Saran onion balloons by gathering the ends and attaching the fittings, proved suitable so far as the sealing operation is concerned. However, the use of a straight bar sealer for this type of work, in which the material must be drawn through the machine as successive overlapping seals are made to produce one seam, is not the most efficient way to make Saran balloons. It is, of course, limited to balloons which can, like the onion or any cylinder balloon, be constructed solely of straight seals. With the mobile electronic sealer which, at this writing, is about to receive its first test, it will be possible to make Saran balloons of any desired shape. Since the Saran seal is nearly as strong as the material, the electronic sealer will be applied to the problem of making a spherical balloon of Saran, in which the serious problems mentioned above will be avoided.

B. Polyethylene-on-Mylar

The one onion-shaped balloon of this material,which was brought back to the laboratories after the others of the same production run had been flown at Pierre, South Dakota, will be laboratory-tested and studied in an attempt to determine what modifications might be made to improve its ability to withstand internal pressure. See Section IV-A.

C. Polyethylene Impregnated Fiberglas

On 21 July 1954, we wrote the Dobeckmun Company to inquire about the results of their work with the polyethylene impregnated fiberglas. At this writing, we have had no reply to our inquiry.

III. EXPERIMENTS EXECUTED

A. Laboratory

1. The testing of the tensile properties of Saran at low temperatures has gone forward since the reinstallation of the cold box on the tensile tester. Two formulations were tested: Q853.3 and Q853.7. Three samples were broken of each formulation, for lengthwise and transverse direction, at 5°C. intervals from -40°C. to -65°C., making a total of 72 tests. The ultimate stresses recorded show a considerable scatter (Drawings A-16862-A, A-16863-A); however, most lie within a range of 14,000 to 23,000 psi. Since the weakest portion of the material determines the over-all strength, the working stress to be used cannot be over 13,000 or 14,000 psi. at the temperatures expected.

There is a curious pattern in the data for Saran Q853.3. At -55°C. and -65°C. the ultimate stress appears to be considerably greater than at the other temperatures. This could be caused by a set of non-valid tests, or possibly by a discontinuity which occurs at the point where the material fractures from cold brittleness. Evidence of this type of fracture was noticed in several of the lowest temperature tests.

Ultimate stress of the Q853.7 formulation seems to decrease gradually from a maximum at about -55°C.

2. On 21, 22, and 23 June, inflation tests of the three types of balloons, about to be flown at Pierre, South Dakota, were made.

a. The Saran A517 onion-shaped balloon was inflated with helium until buoyant equilibrium was reached. The normal flight load of 12 pounds, consisting of the exact equipment being flown for pressure telemetering, was supported by the balloon when this weigh-off was accomplished. The balloon was then inflated to fullness with nitrogen to avoid increasing the lift significantly above that experienced in flight, so that unusual stresses on the balloon at its tie-down point would not develop. Photographs taken during the inflation test of the Saran balloon are numbered 8138, 8139, 8140, 8141.

The balloon was very near its final shape when the first pressurization was noticeable. Both the pressure telemetering unit and the water manometer were connected to the line leading into the balloon and were read periodically as the pressure was increased. The data taken at that time are recorded in Table I below.

During the inflation, a large crease in the balloon extended from the top fitting down past the equator and was never completely removed. It may have contributed to the balloon's failure which occurred at that point. The crease or fold referred to consists of the excess of circumferential material which has nearly all collected at one meridian.

Table I

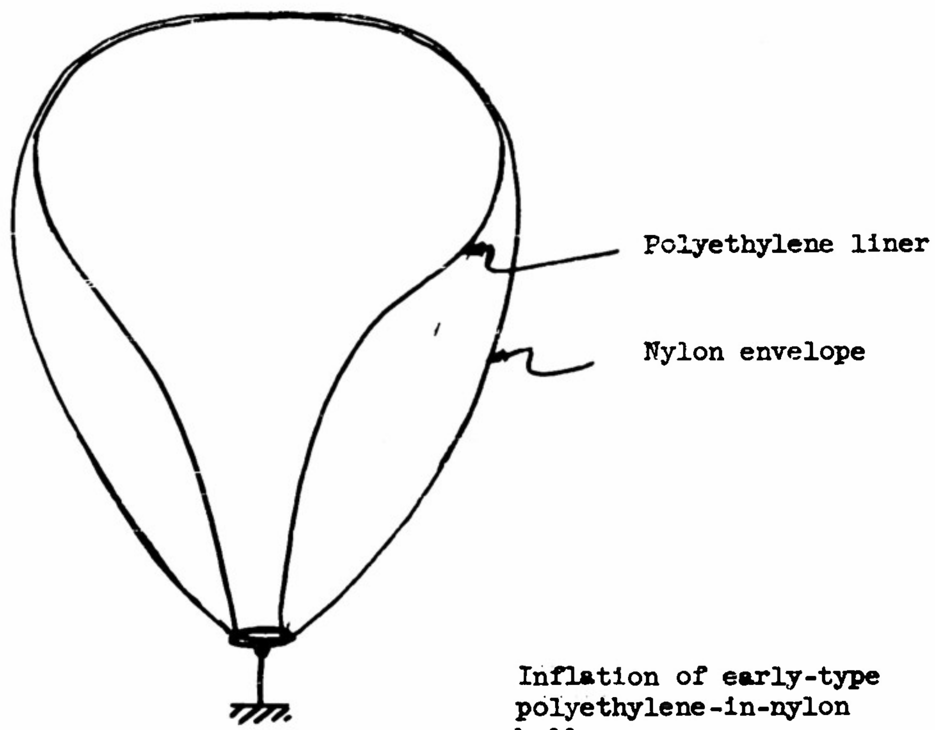
Code	Mb.	Water Manometer	
I(part of N)	983.0	1/8"	1/8"
N		5/8"	5/8"
NMU	983.7	3/8" x 2 =	3/4"
NMM	984.0	7/16" x 2=	7/8"
NMN	984.5	9/16" x 2 =	1 1/8"
NMS	984.7	9/16" x 2 "	1 1/8"
NMI	985.0	≃5/8" x 2 =	1 1/4"

The balloon used was designed to contain 1800 cubic feet of gas. Pressurization occurred before that volume had been attained. In efforts to increase the internal pressure, it became apparent that the material was stretching, as an additional 200 cubic feet of gas were introduced without increasing the super-pressure beyond 1 1/4 inches of water. After this reading was obtained, another 20 cubic feet were introduced and, just as the new readings were about to be taken, the balloon burst. The tear was across gores near the upper fitting.

The data indicate that a 10% increase in enclosed gas was attained with only a 0.25% increase in absolute pressure. Assuming the temperature to be constant, the only conclusion to be reached is that the balloon's volume was increased. This type of behavior in plastic films is known as "creep", and it was expected that it would be encountered to some extent in Saran but not to the extent experienced here. The experiment emphasized the fact that, for the testing of Saran super-pressure balloons, either small models must be made and the values obtained must be corrected for thickness of material and temperature, or the full size balloon must be flown in order to put it in an environment where the temperature will give the material the strength which is expected of it.

b. In the inflation test of the 15 foot sphere of polyethylene, in a 15 foot spherical nylon envelope, a reefing sleeve was used in order to control the distribution of the nylon over the polyethylene during the early stages of the inflation. Negligible static build-up was experienced.

It was found that the polyethylene liner was not satisfactory as designed. Since the nylon does not act as a gas barrier, the two cells behaved as shown in the following sketch. The nylon provides no strength to support the load until the balloon is inflated well beyond that point reached on the ground before launching. As the inflation with nitrogen proceeded, it became apparent that modification to take care of two difficulties was necessary. (1) The orientation of the polyethylene with respect to the nylon at one pole of the balloon might not be the same as at the other, and hence a twist in the liner as opposed to the nylon would develop. As the



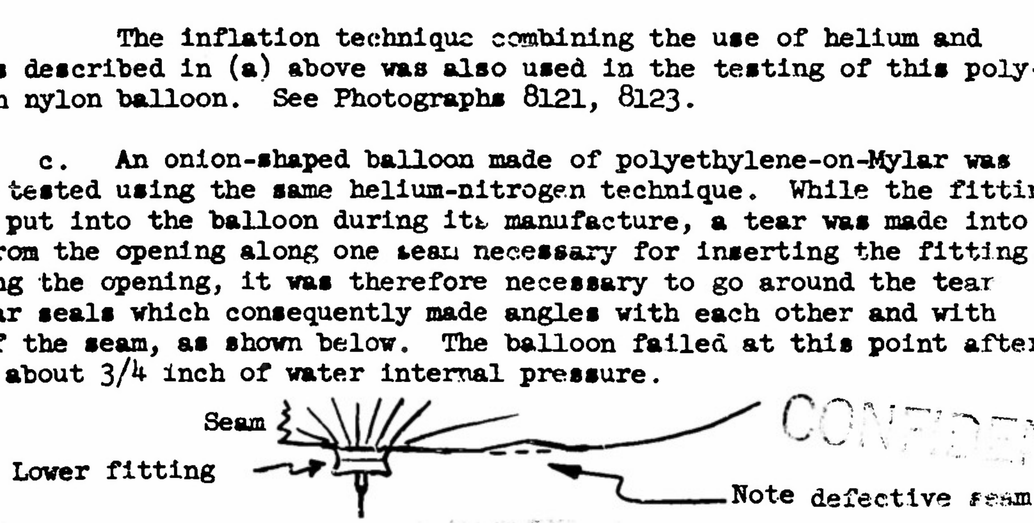
Inflation of early-type polyethylene-in-nylon balloon

balloon reached full inflation, this could produce undesirable stresses. In order to remove this trouble, it was decided that future liners would have to be unattached to the bottom fitting and the balloon inflated through a duct, ~~which would then be sealed and the plate fastened down.~~ There would then be no need for a gas tightness at the fitting connections. (2) The polyethylene liner should be larger than that of the first models, that is, it should be larger than the nylon envelope which encloses it. The ones tested were already designed to be longer than the nylon envelope in the lower section near the appendix, but during the last part of the inflation, with the balloon still far from full, the polyethylene appeared to be making nearly a straight line from the outer circumference down to the appendix, and the nylon had some slack. It was decided to have later polyethylene liners made to a diameter of 17 ft.

Before the inflation was complete, a hole was found to have been torn in the polyethylene near the appendix by the incoming gas. This fault will be removed by the modification mentioned in (1) above.

The inflation technique combining the use of helium and nitrogen as described in (a) above was also used in the testing of this polyethylene in nylon balloon. See Photographs 8121, 8123.

c. An onion-shaped balloon made of polyethylene-on-Mylar was laboratory tested using the same helium-nitrogen technique. While the fittings were being put into the balloon during its manufacture, a tear was made into one gore from the opening along one seam necessary for inserting the fitting. In resealing the opening, it was therefore necessary to go around the tear with two bar seals which consequently made angles with each other and with the rest of the seam, as shown below. The balloon failed at this point after developing about 3/4 inch of water internal pressure.



The inflation was found to be much simplified by the use of a polyethylene "reefing sleeve" made from 30 inch layflat material. However, it is doubtful that the large crease, or accumulation of folds, can be completely removed by any technique, after the reefing sleeve has been removed. Time and again, the material was distributed by hand more evenly about the crown of the balloon, but it seems to be an unstable situation. Unless all of the folds are exactly equal, an impossible situation, the material will automatically distribute itself such that the excess is all gathered in one fold. It appears that the slightest inequality in distribution causes the larger folds to gain material from the smaller ones and, in the end, the largest fold acquires all of the excess material. Photographs numbered 8127, 8132, 8134, and 8136 show the inflation test of the polyethylene-on-Mylar balloon.

B. Flight

The field trip to Pierre, South Dakota, where 12 balloons were flown, was planned optimistically to make certain that no data were lost due to the balloons' passing beyond the radio horizon. Since all telemetering was to be on 40 megacycles, this meant that the radio horizon was essentially the visible horizon, and we could not expect reception after the balloon had passed more than 100 to 150 miles away. It was thought necessary, therefore, to have three receiving stations to record the data from the balloons. One was located at the launching site at Pierre Municipal Airport, another at Minneapolis at the General Mills Laboratory, and a third was located in an automobile which had been especially equipped to receive the signal. The automobile was to be located on the South Dakota-Minnesota border and to move north and south on that border in accordance with instructions sent out from Pierre on 6420 kilocycles. Communications between Pierre and Minneapolis were also scheduled to be handled by radio on 6420 kilocycles. After a few flights, the mobile receiving station was returned to Minneapolis to be called out only after a balloon might prove itself capable of floating beyond the range of the receiving station at Pierre. This was never found necessary.

On each flight, the balloon was weighed-off with the greatest precision possible inside the hangar at Pierre Municipal Airport. With the exception of Flight #1206, all of the balloons were sealed after weigh-off with the intention that the free lift gas be contained.

Superheat in an onion-shaped balloon might be expected to exceed that of a spherical balloon or any other balloon in which there is no such excess of material.

1. Flight #1129 (A-21322-B)

The first flight of a Saran onion-shaped balloon carrying pressure telemetering equipment was characteristic of the majority of those to follow. Launched in the early evening of the first day at Pierre, after the radio equipment and antennas had been installed, the balloon rose to an altitude which indicated that at that point it had a volume of 1490 cubic feet, and then descended gradually to the ground. The entire flight lasted only slightly more than three hours.

During its ascent, the balloon commenced to pressurize at that point where its volume was approximately 1,080 cubic feet. This was at 21,000 feet MSL. The pressure telemetering instrument indicated that there it developed an internal pressure of approximately 0.25 inches of water, and that this pressure was maintained until 10 minutes after the balloon had reached its maximum altitude of 30,000 feet, at which time it had already begun its descent. Apparently this low internal pressure was sufficient to expel the free-lift gas from the balloon through some already existing hole. Since the balloon was constructed of Saran A517, which is not the formulation which is noted for its cold brittleness temperature, it is possible that flexing at the low temperature region of the atmosphere caused the balloon to develop a leak. However, the temperatures which it experienced were never below -35°C., and if the balloon had ruptured, the tear characteristics of Saran are such that it is more likely that the balloon would have split wide open and descended rapidly. Since this was not the case, the balloon having descended at approximately 250 feet per minute, it is more likely that the free-lift gas was forced out through a hole which was already in the balloon at time of launching.

2. Flight 1130 (Drawing A-21329-B)

Temperature telemetering on this flight of a 10-foot spherical balloon consisting of 1.1 ounce nylon fabric enclosing a 1.5 mil polyethylene bladder, indicated a super-heat of approximately 13°C. during a floating period of approximately 10 minutes at 32,000 feet. The data do not indicate that the temperature of the nylon and of the helium within the balloon, which appeared to be nearing equality during the floating period, ever reached the equilibrium condition before the balloon began to descend. It must be allowed, therefore, that the super-heat for a floating balloon under these conditions might be greater than that indicated on this flight. Although the load was suspended from fittings attached at the equator of the balloon and the only weight hanging at the appendix was that of the appendix ring, the balloon never attained its theoretical volume. Since a similar balloon on Flight #1177 noticeably exceeded its theoretical volume when under internal pressure, it might be assumed here that the balloon never did pressurize significantly, but was able to exhaust its free lift through a leak so easily that the spherical shape was never attained.

3. Flight #1172 (Drawing A-21328-B)

Temperature telemetering on this flight of an onion-shaped balloon of Saran Q853.3 indicates a temperature gradient in the gas within the balloon extending from the warmer temperatures near the top of the balloon to the lower temperatures near its base. Before reaching its theoretical ceiling, but after commencing to pressurize (as indicated in the data from Flight #1129), the balloon apparently split open suddenly before the temperature of the gas had reached its equilibrium condition. A maximum super-heat indicated here was 8°C. It should be noted that the type of descent experienced on Flight 1172 with a balloon constructed of Saran Q853 material is notably different from that of Flight #1129 with A517 Saran. The interpretation here would be that the balloon contained its pressure well as it continued to rise beyond the point reached by Flight #1129, and up to the point of rupture, rather than exhausting its free lift gradually through a hole which already existed.

4. Flight #1173

This flight of a polyethylene-on-Mylar onion-shaped balloon carrying a pressure telemetering equipment failed to provide any useable data. The Brailsford motor stopped running after approximately 25 minutes of operation, apparently due to the depletion of the battery power. A EAK 4 barograph carried on the flight also was of little value since the trace on a smoked disc was destroyed by smudging during handling before the barograph was returned to the laboratories.

5. Flight #1174 (Drawing A-21331-B)

Temperature telemetering on this flight of a polyethylene-on-Mylar onion-shaped balloon which floated for approximately 10 minutes at its theoretical ceiling indicates a superheat of approximately 22 degrees. In this case, the recorded data indicate that the gas within the balloon had reached its equilibrium temperature with respect to its surroundings, and that the superheat recorded would be the maximum to be expected under these conditions. The 22°C. figure is approximately one-half of the value for superheat which has been used in the design of these balloons. Since this was an onion-shaped balloon and since it did reach its theoretical ceiling, it must be assumed that the balloon was under internal pressure during its floating period; for, otherwise, its theoretical volume could not have been attained, especially with the load being suspended from its lower fitting. This would indicate that the polyethylene-on-Mylar material has promise in an onion-shaped balloon and that the trouble lies in the problem of making a balloon which is absolutely hole-free, although in this case it was not quite so pronounced as in Flight #1172 with a Saran balloon.

It is possible, of course, that the temperature readings during the floating and for a short time thereafter are in error for the gas within the balloon, as well as they were apparently in error for the free air, although the record of the gas temperature as shown is reasonable, while that of the free air would be hard to explain.

6. Flight #1175

This flight of an onion-shaped balloon constructed of Saran A517 material and carrying a pressure telemetering unit also failed to provide any data, due to the fact that the transmitter quit within 5 minutes after takeoff. Examination of the batteries in the remaining pressure telemetering units revealed some were not up to strength and these were replaced.

7. Flight #1176 (Drawing A-21330-B)

Temperature telemetering equipment flown on this spherical balloon, constructed of 2.5 ounce nylon fabric enclosing a 1.5 mil polyethylene bladder, indicated a temperature difference of approximately 13°C. between the balloon skin and free air at the maximum altitude reached. The time altitude curve indicates that the balloon burst at this point which was somewhat short of its theoretical ceiling. Since the balloon was not recovered, it is impossible at this time to determine whether or not the polyethylene bladder alone was responsible for the failure, as it was in another flight of this balloon type. The bladder in this balloon was of a diameter 2 feet larger than the enclosing nylon envelope.

It is interesting to note that the temperature data obtained from the thermistors on the balloon agrees well with the flight performance, which showed the balloon to be temporarily halted in its ascent by an inversion near the ground.

8. <u>Flight #1177 (Drawing A-21327-B)</u>

The 1.1 ounce nylon sphere flown on this flight enclosed a bladder consisting of a 500 gram Kaysam balloon, manufactured by the Molded Latex Products Co. of Patterson, N. J. The pressure telemetering instrument flown on this balloon indicates that, at the level where the volume of the balloon was 444 cu. ft., internal pressure commenced to develop and continued to build up until a super-pressure of 11 inches of water was reached. At this point, the balloon burst. Under this pressure, the nylon envelope stretched considerably, since the maximum altitude reached indicates a volume of nearly 100 cu. ft. more than the unstretched volume of the balloon.

Upon examination of the balloon after its return to the laboratories, it was revealed that the nylon envelope had been torn completely away from the collection ring at the point where it was attached, and the several tears had propagated up the seams nearly to the equator. The entire amount of damage to the balloon was limited to the lower hemisphere, as would be expected, since nearly the weight of the appendix ring would distort the shape in that part of the balloon making it less than a perfect sphere. The load had been suspended from loops attached at the equator of the balloon.

Of major interest in the evaluation of the type of seam used in joining the gores in the nylon envelope is the fact that none of the seams exhibited any signs of having been strained by the internal pressure, except where they had been torn as the burst section propagated. A different type of fitting at the appendix might make this type of balloon successful. It should be noted that the fact that the balloon containing the rubber bladder is the only one which withstood any significant internal pressure would seem to confirm the conclusion reached earlier that one of the major problems is that of producing an absolutely hole-free balloon.

9. <u>Flight #1178 (Drawing A-21326-D)</u>

The temperature telemetering equipment flown on this 2.5 ounce nylon spherical balloon containing a 1.5 mil polyethylene bladder malfunctioned so that no data on superheat were obtained. However, the altitude information was received and indicated a period of floating of 21 minutes at theoretical ceiling. The slow descent indicated that the failure of this flight was due to a leak in the balloon, and upon recovery it was discovered to consist of a fault in the seal at the crown of the balloon, which left a slit approximately 1.25 inches long at that point. It is impossible to say what type of flight this might have been had the polyethylene bladder been without this imperfection.

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10. Flight #1179 (Drawing A-21325-B)

The data obtained from the pressure telemetering instrument flown on this onion-shaped balloon constructed of 1.5 mil polyethylene on 1 mil Mylar appears questionable. Since the balloon not only went to its ceiling but actually exceeded it, it must be assumed that it was pressurized considerably; for it is impossible to attain the true shape of an onion-shaped balloon,and thereby to attain its full volume, without pressurizing the balloon. Here, again as in Flight #1174 where a balloon of the same construction was flown and where again the balloon arose slightly above its theoretical ceiling, no burst occurred. Flight #1179 further substantiates the conclusion that the polyethylene-on-Mylar material in an onion-shaped balloon warrants further study.

11. Flight #1180 (Drawing A-21323-B)

The telemetering data obtained from this flight of an onion-shaped Saran balloon would seem to indicate that the balloon contained a hole at the time of launching since it did not reach its theoretical ceiling, and since the slow descent would not occur had the balloon burst due to its internal pressure. Here, a pressure telemetering record shows small fluctuations of the internal pressure throughout the flight, which can only be attributed to vibration of the pen arm which must have been resting on the border between two code sections.

12. Flight #1206 (Drawing A-21324-B)

Temperature telemetering equipment flown on this onion-shaped balloon of polyethylene-on-Mylar material again indicated a temperature gradient in the gas within the balloon extending from lower temperatures in the base of the balloon to warmer temperatures near the top. The superheat indicated by data from this flight amounted to a temperature difference of approximately 12°C. However, it should be noted that the free air temperature used for this comparison was that of the Weather Bureau observation at the time of the flight. The free air thermistor had been damaged during the launching.

The superheat of 12° was merely the maximum superheat attained and was at the point of bursting. It would be useful in determining the internal pressure which was developed, but it was not an indication of the superheat to be expected of this type of balloon, since the balloon had not begun to float and hence the temperature of the bas within the balloon was not that of the equilibrium condition.

Note: In the reporting of the analysis of each flight on which temperature telemetering equipment was flown, the super-pressure which was indicated by the superheat that was measured should be noted.

IV. EXPERIMENTS PLANNED

A. Laboratory

Since none of the balloon types which were originally selected for study under this project has proved successful in the form developed so far, new designs are being pursued as reported below. This does not mean, however, that the types already under study are being discarded, but rather that their performance so far has indicated that certain problems such as gas tightness are more serious than originally realized, and that designs which offer a simpler way of overcoming this difficulty should be investigated.

1. Onion-shaped balloons

Onion-shaped balloons constructed of Saran and of polyethylene-on-Mylar will be subjected to further laboratory tests using modified end fittings and variations in the diameter to length ratio, in an attempt to produce a balloon which will stand the internal pressures which onion-shaped balloon theory says are possible.

2. Electronic sealer for Saran film

Tests of an electronic sealer will be made to determine that its folding mechanism works properly to provide a lap seal, and to determine the proper running speed, power setting, and electrode spacing for production operation.

3. Spherical Saran balloons

When the test runs for the electronic sealer mentioned above have been completed, spherical balloons of Saran will be constructed, laboratory-tested, and flown.

4. Cylindrical balloons

Experiments are planned which will test several different forms of a cylindrical balloon roughly 8 ft. in diameter and 44 ft. long which would offer some advantages in overcoming the difficulties which have been encountered with the other designs. With a diameter of only 8 ft., the pressure within the balloon would develop approximately the same stress in the balloon's walls, due to the fact that it is cylindrical rather than spherical in shape. However, this design offers several distinct advantages. The design being studied is that of a cylinder each of whose ends are sealed by one transverse seam, except for one corner at which an extension of the material is formed into a small tubular appendix. The design shape for a shroud for this balloon, in which two appendices are included for instrumentation purposes, is shown in Drawing A-16819-A. Productionwise, this design has the advantage of great simplicity, and also the most troublesome feature in the production of the other types of balloons - the attachment of fittings - is completely avoided.

An additional advantage is found in the fact that, unlike the other balloons, the suspension of a load from one corner will not cause a distortion in the shape which would produce a weakened section. Reference here is to the fact that, in both the onion shape balloon and the spherical balloon, the weight of the appendix ring or fitting, or either of these plus the load, tends to increase the radius of curvature and consequently to increase the tensile stress in the film in that section of the balloon. In a balloon of a shape shown in Drawing A-16819-A, with the payload suspended from one corner, we are dealing with that section of the balloon whose radius of curvature is already much smaller than the major dimension, and which is not adversely affected by the suspension of the load.

The weight of such a balloon constructed of the heaviest material, Saran, would be approximately 19 lbs. and would be capable of carrying a 10-lb. payload at 42,000 ft. Four-mil polyethylene and thinner weights of polyethylene with nylon covers, or with strengthening tapes, will be tested.

5. The scalloped balloon

Another suggested design is that of a polyethylene sphere reinforced by tapes running meridionally from pole to pole in such a way that the meridional stresses are taken up by the tapes, and the circumferential stresses by the polyethylene which, under pressure, billows out between the tapes with radii of curvature which are small enough to prevent the stresses from exeeding the limits of strength of the polyethylene.

6. Super-pressure

Using the laboratory technique developed earlier in the project, and recorded and described in Report #1289, p. 10, superheat comparisons will be made to investigate the relative superheat to be expected from the materials actually used in the balloons developed so far under this project. Using a 1.5 mil polyethylene balloon as a control, specimens constructed of 1.5 mil polyethvlene on 1 mil Mylar and of 2 mil Saran will be used in this experiment.

B. Flight

Additional flight experiments will be made after laboratory tests of any balloon type have gained as much information as can be gained on the ground and have indicated that the balloon type is feasible. Telemetering of altitude and either temperatures or super-pressures will be made as in past flights under this project.

V. FINANCES

The total of funds committed as of 31 July 1954 was $33,377. Of this amount, $22,574 was labor and burden. Funds remaining amount to $23,068.

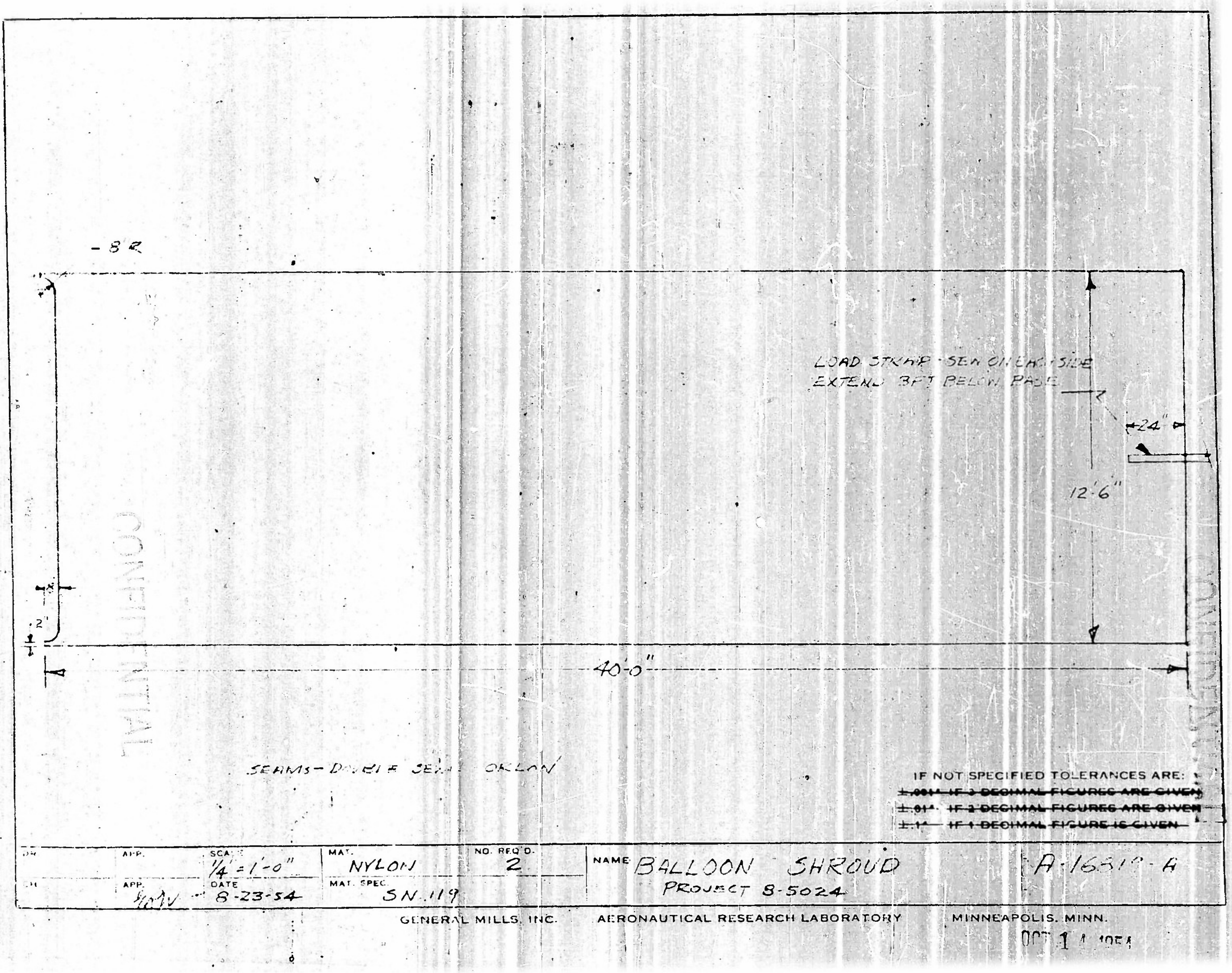
APPENDIX

PHOTOGRAPHS

Photograph No.	
8121	Early stage of inflation of polyethylene-in-nylon balloon.
8123	Maximum inflation of polyethylene-in-nylon balloon before ruptured polyethylene near appendix.
8125	Fully-inflated Saran onion showing unequal distribution of meridional stresses.
8127	Attempt to distribute the slack material uniformly around the crown of a polyethylene-Mylar balloon.
8131	Fully-inflated polyethylene-Mylar onion. Some material is slack, while other portions (note straight lines from fittings) carry stress.
8132	Top view of polyethylene-Mylar onion balloon fully inflated.
8133	Polyethylene-Mylar onion pressurized to one inch of water. Note stress lines crossing seam at an angle in center of picture.
8134	Polyethylene-Mylar onion with one inch water pressure.
8136	Polyethylene-Mylar onion being inflated with reefing sleeve.
8138	Saran onion just before pressurization.
8139 8140	Partially inflated Saran onion showing the gathering of excess material into a fold.
8141	Saran onion partially inflated.

DRAWINGS

Drawing No.	
A-16819-A	Nylon shroud for fully stressed cylinder balloon.
A-16862-A	Breaking stress of Saran Q853.7 at low temperatures.
A-16863-A	Breaking stress of Saran Q853.3 at low temperatures.
A-21322-B	Time-Altitude and super-pressure curve for Flight #1129.
A-21323-B	Time-Altitude and super-pressure curve for Flight #1180.
A-21324-B	Time-Altitude and temperature data for Flight #1206.
A-21325-B	Time-Altitude and super-pressure curve for Flight #1179.
A-21326-B	Time-Altitude curve for Flight #1178.
A-21327-B	Time-Altitude and super-pressure curve for Flight #1177.
A-21328-B	Time-Altitude and temperature data for Flight #1172.
A-21329-B	Time-Altitude and temperature data for Flight #1130.
A-21330-B	Time-Altitude and temperature data for Flight #1176.
A-21331-B	Time-Altitude and temperature data for Flight #1174.



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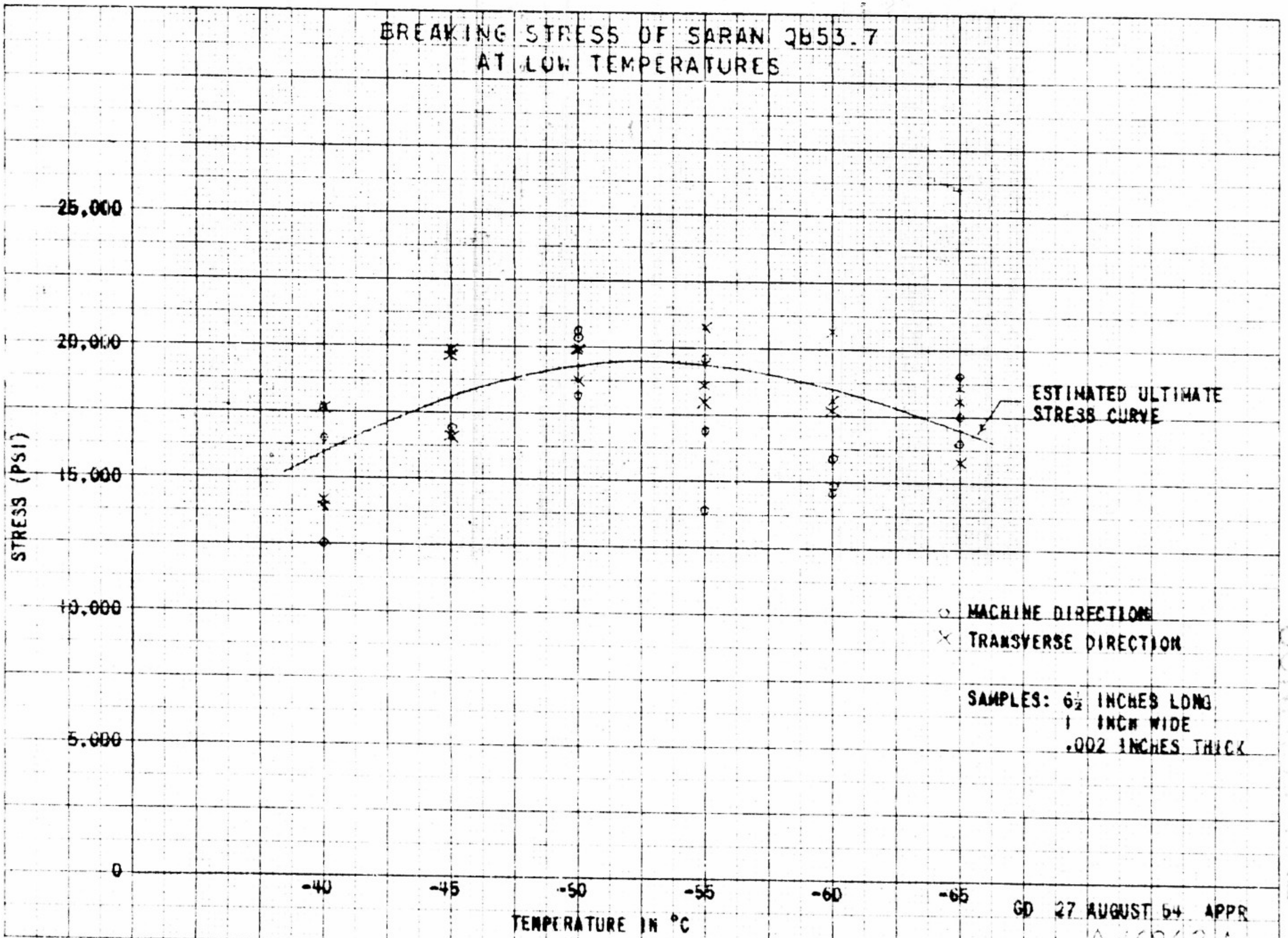

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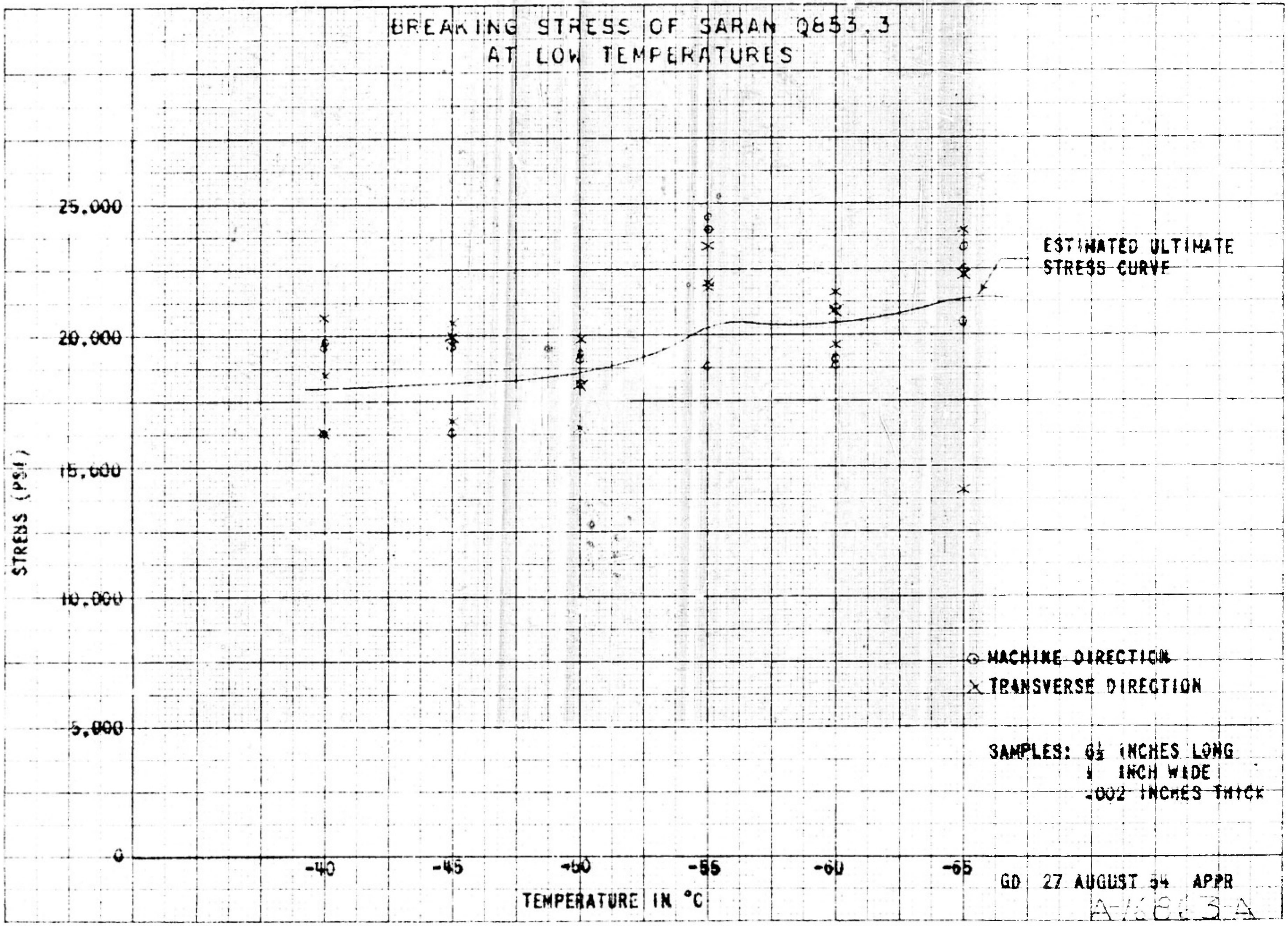

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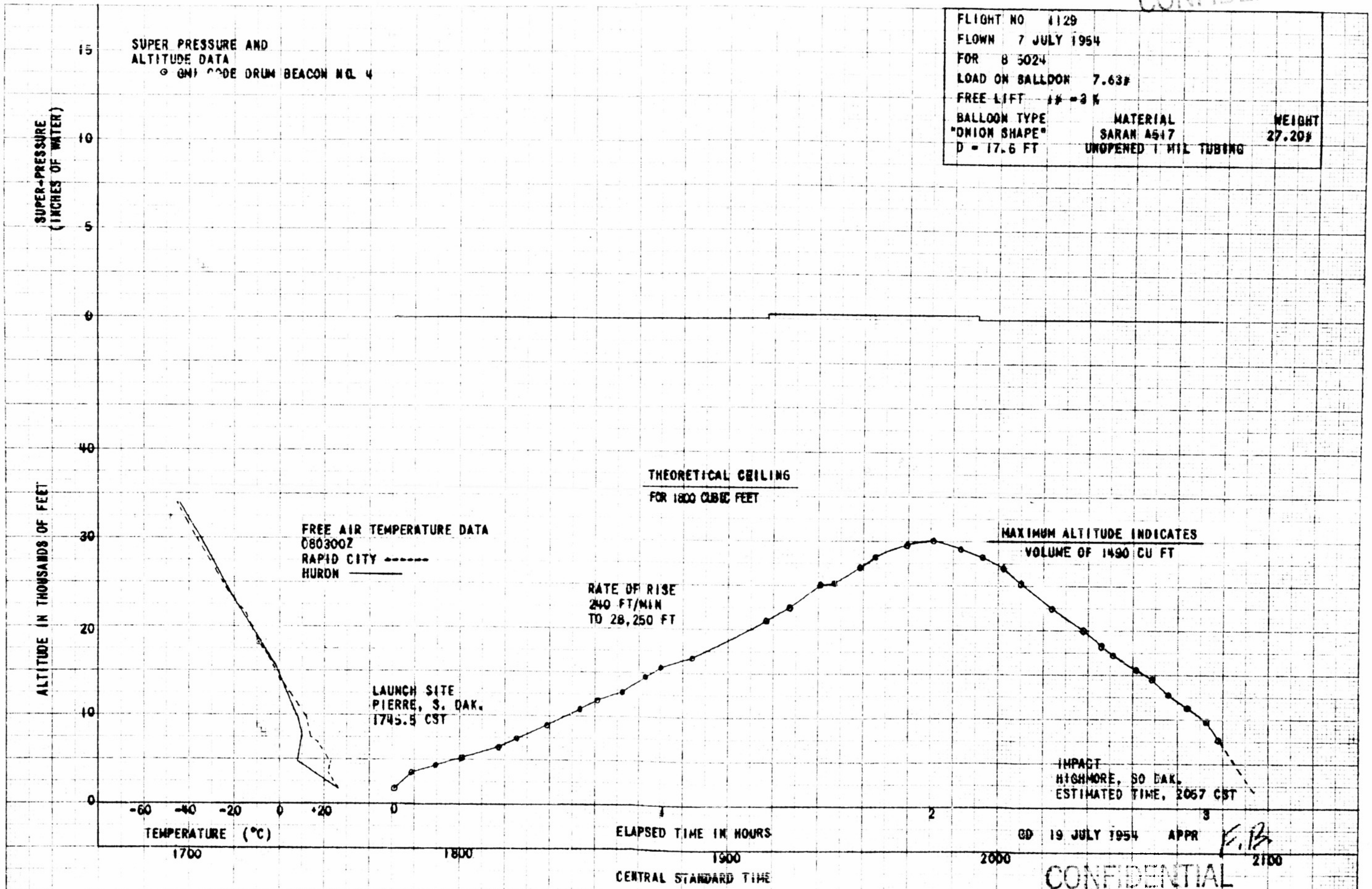

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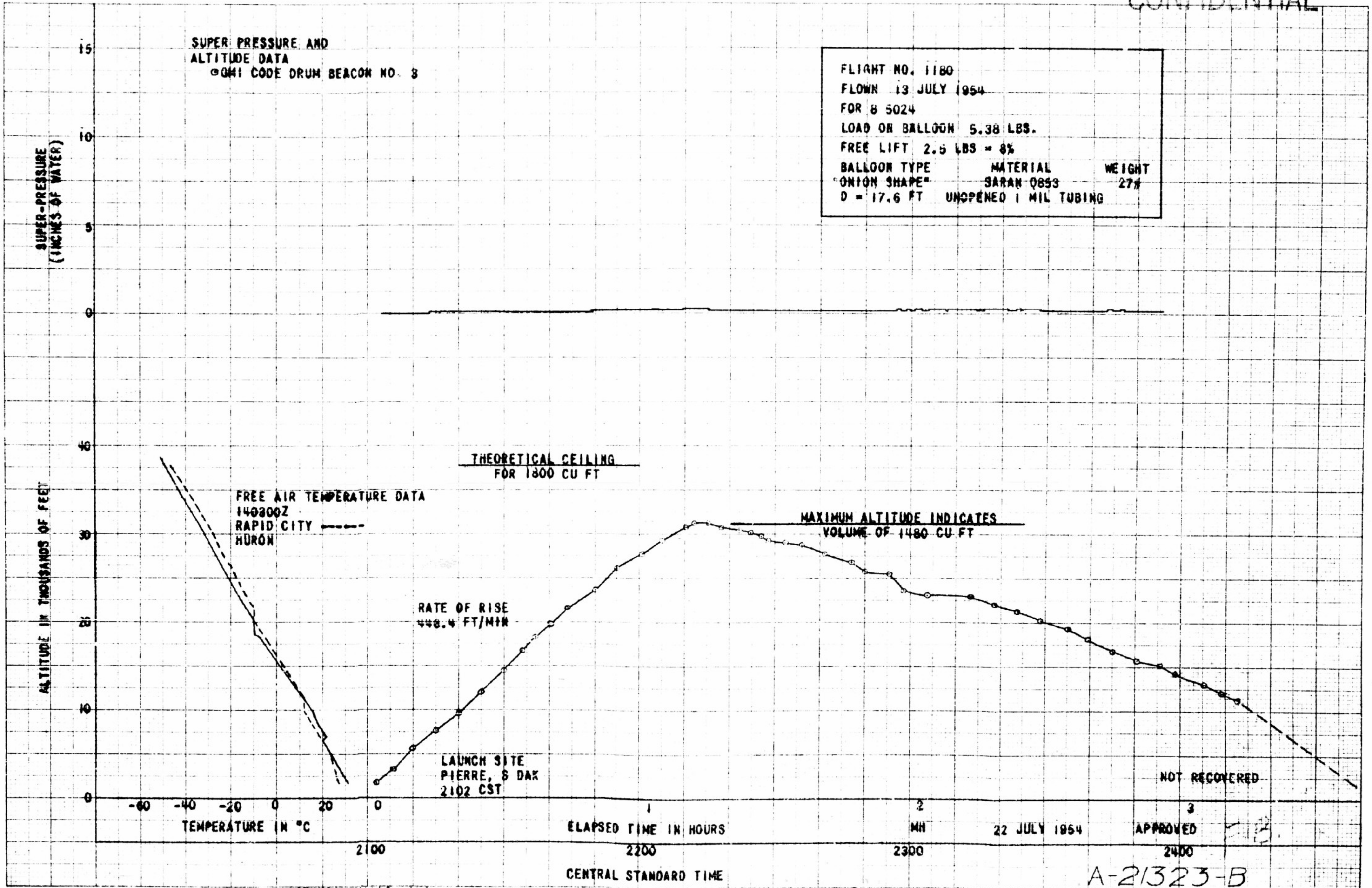

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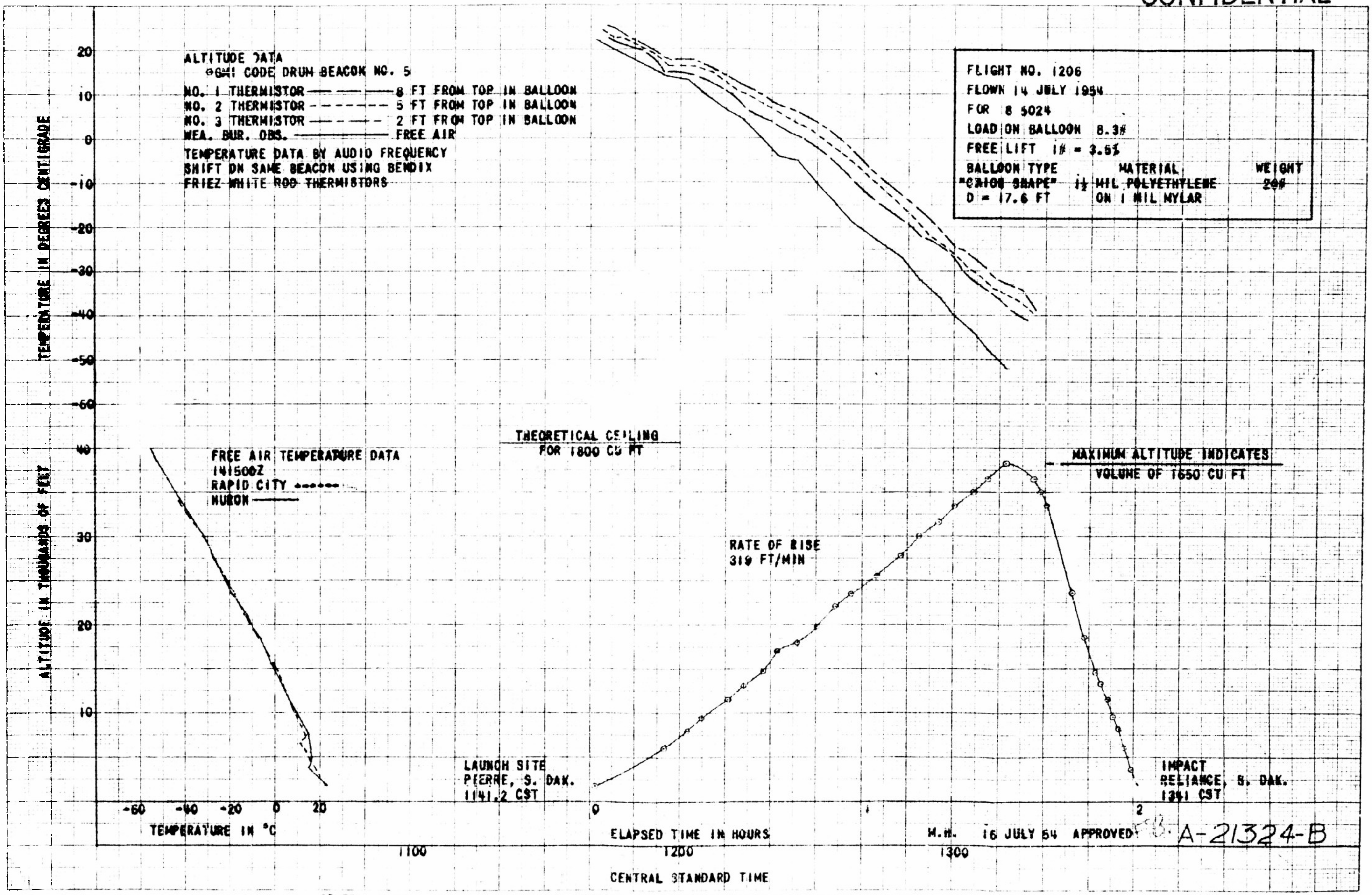

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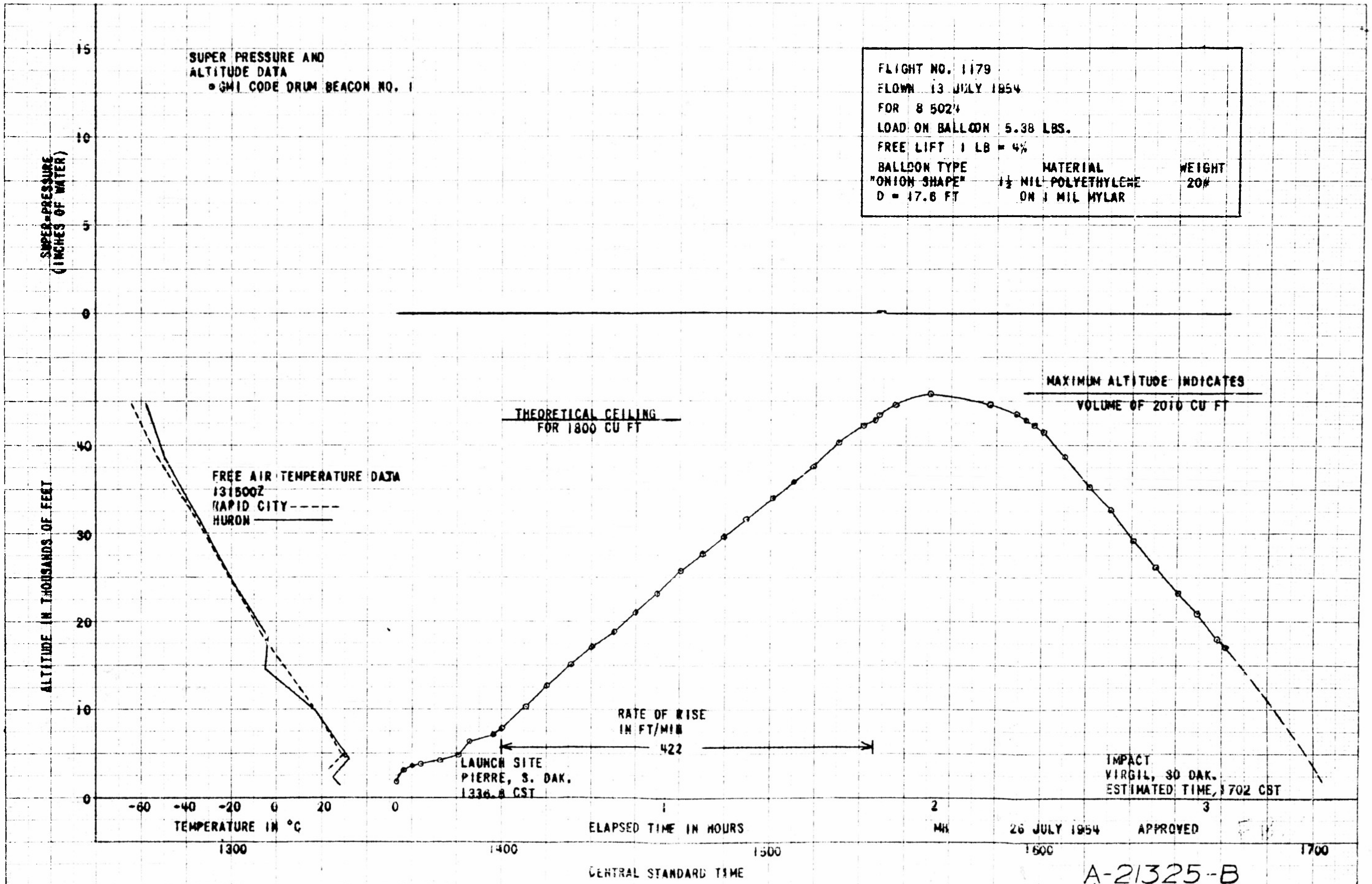

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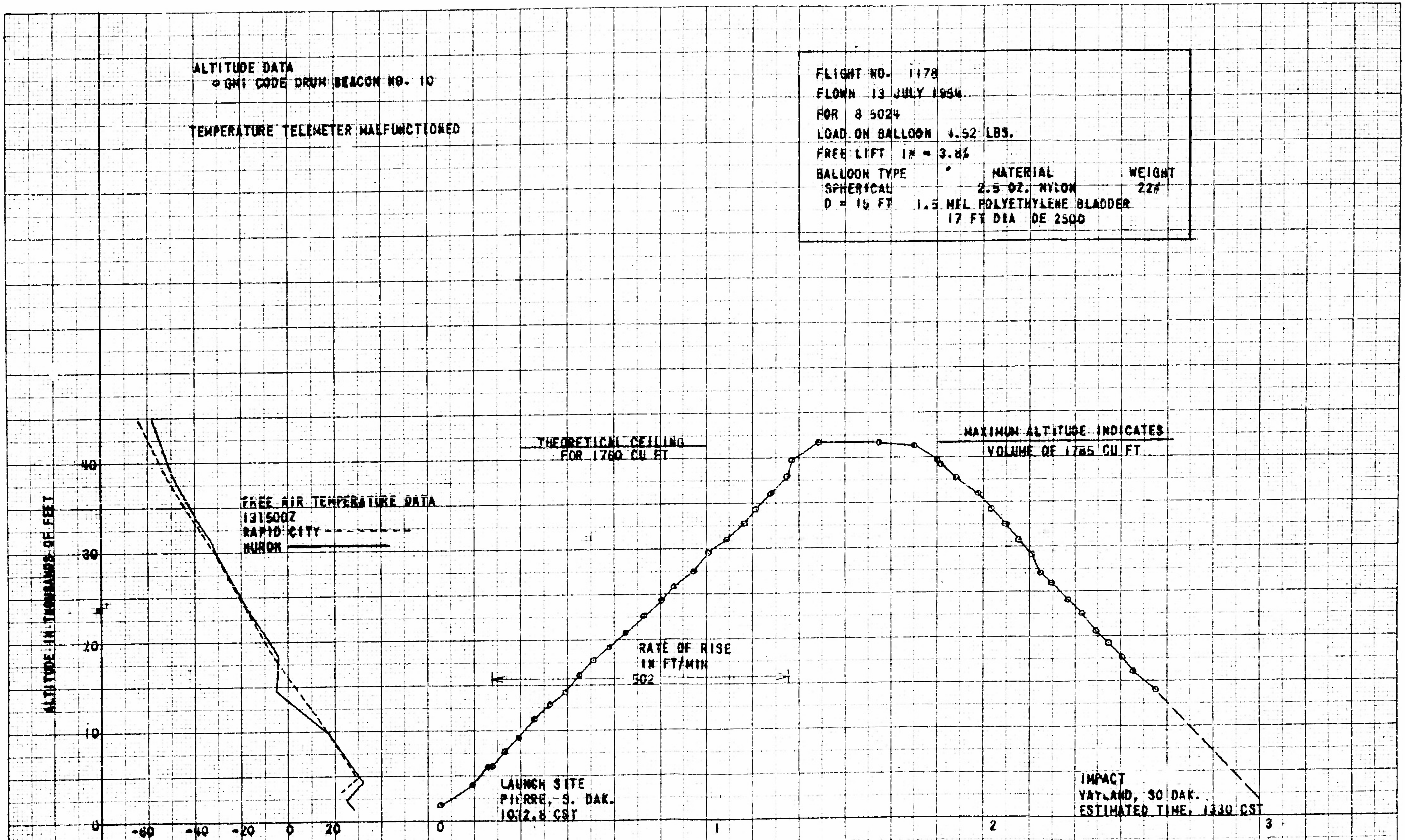

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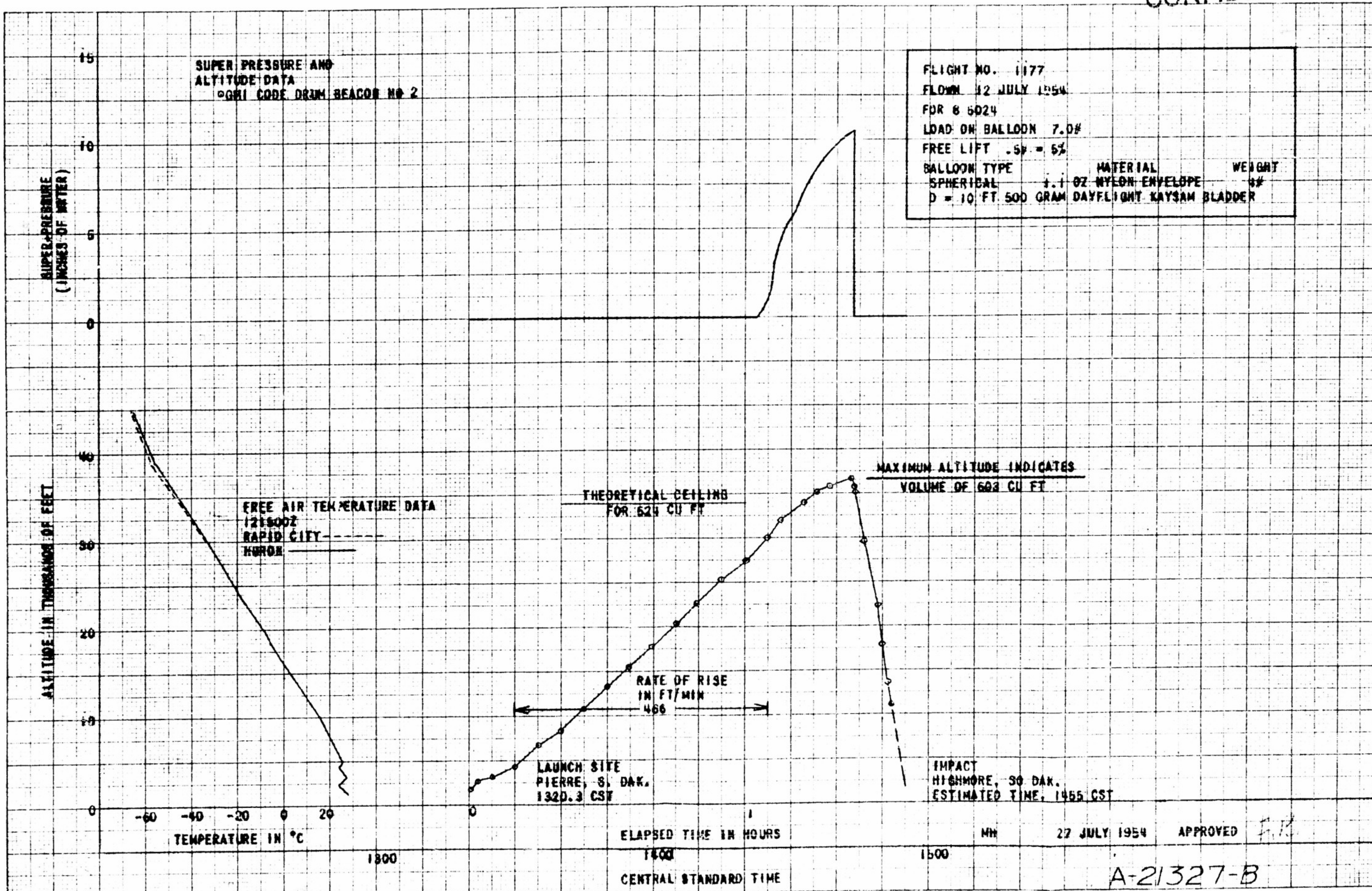

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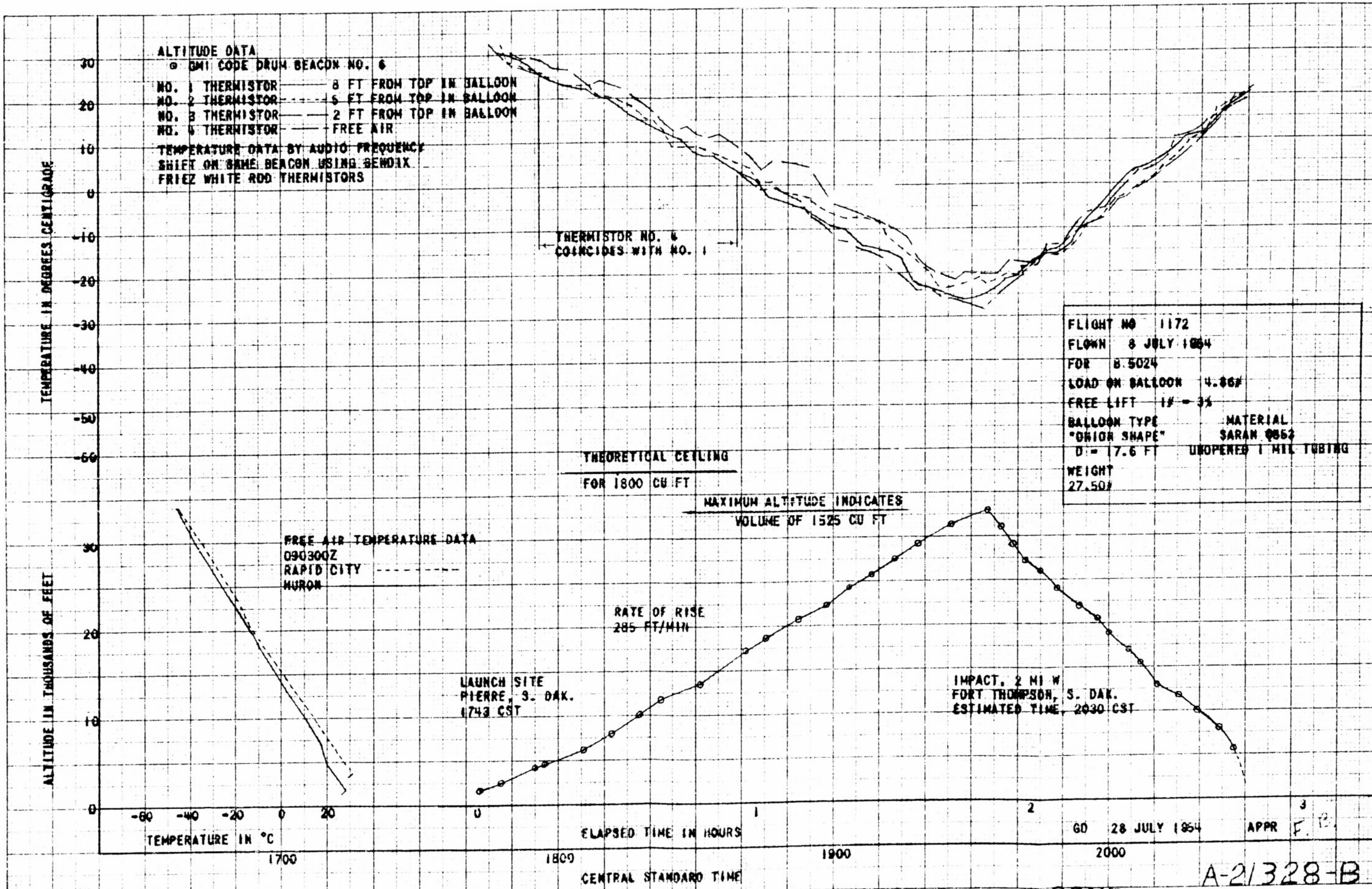

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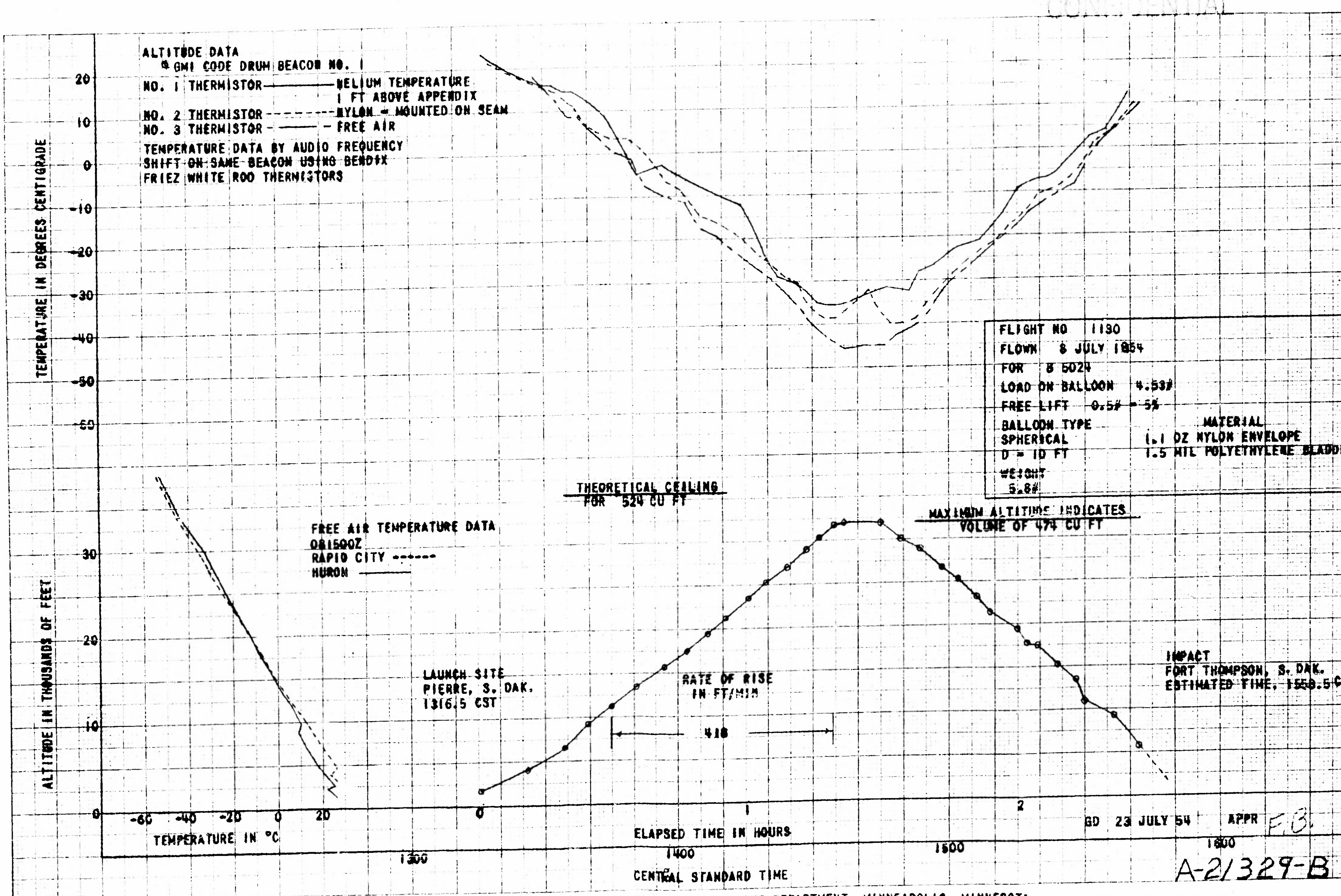

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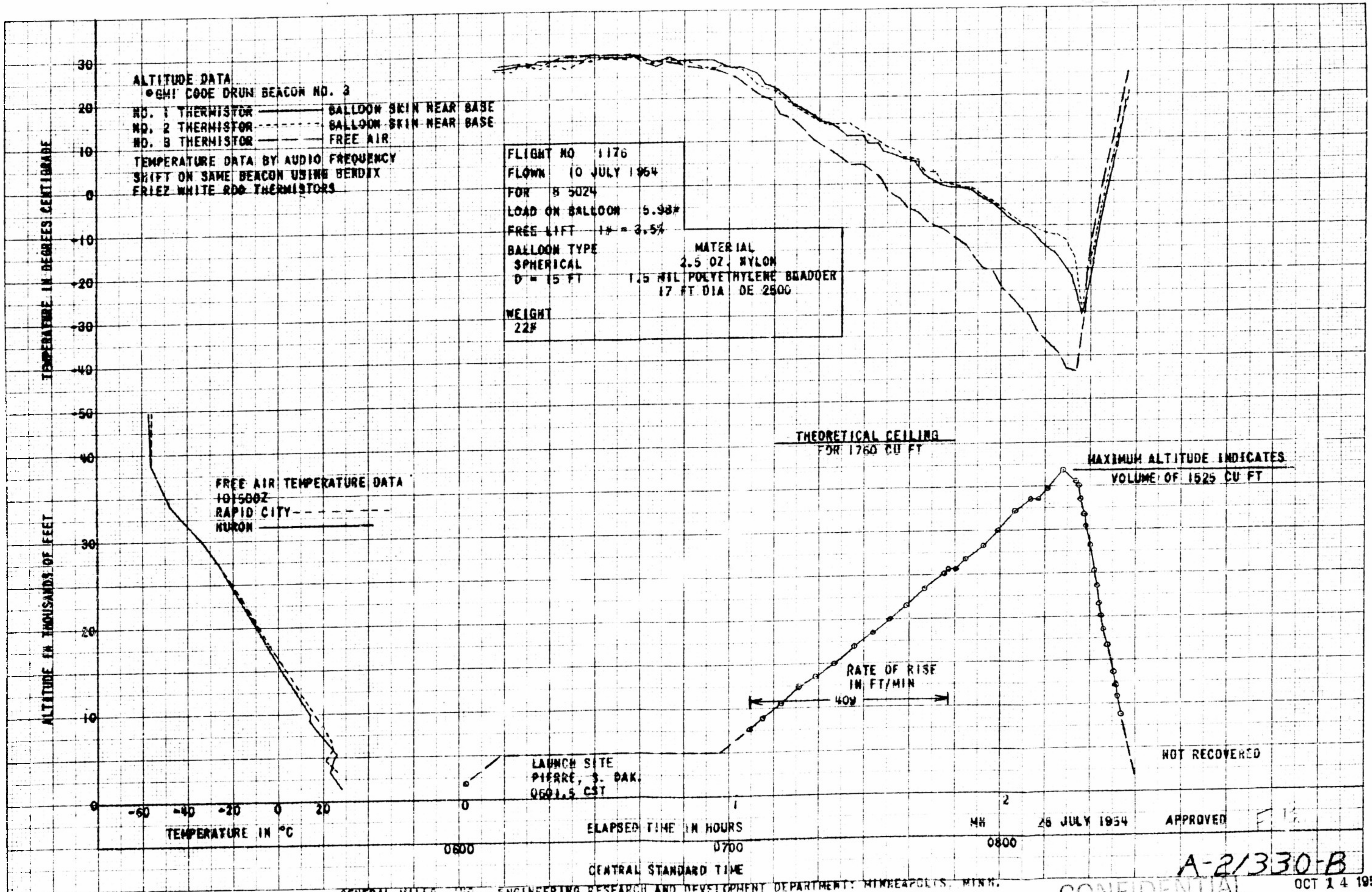

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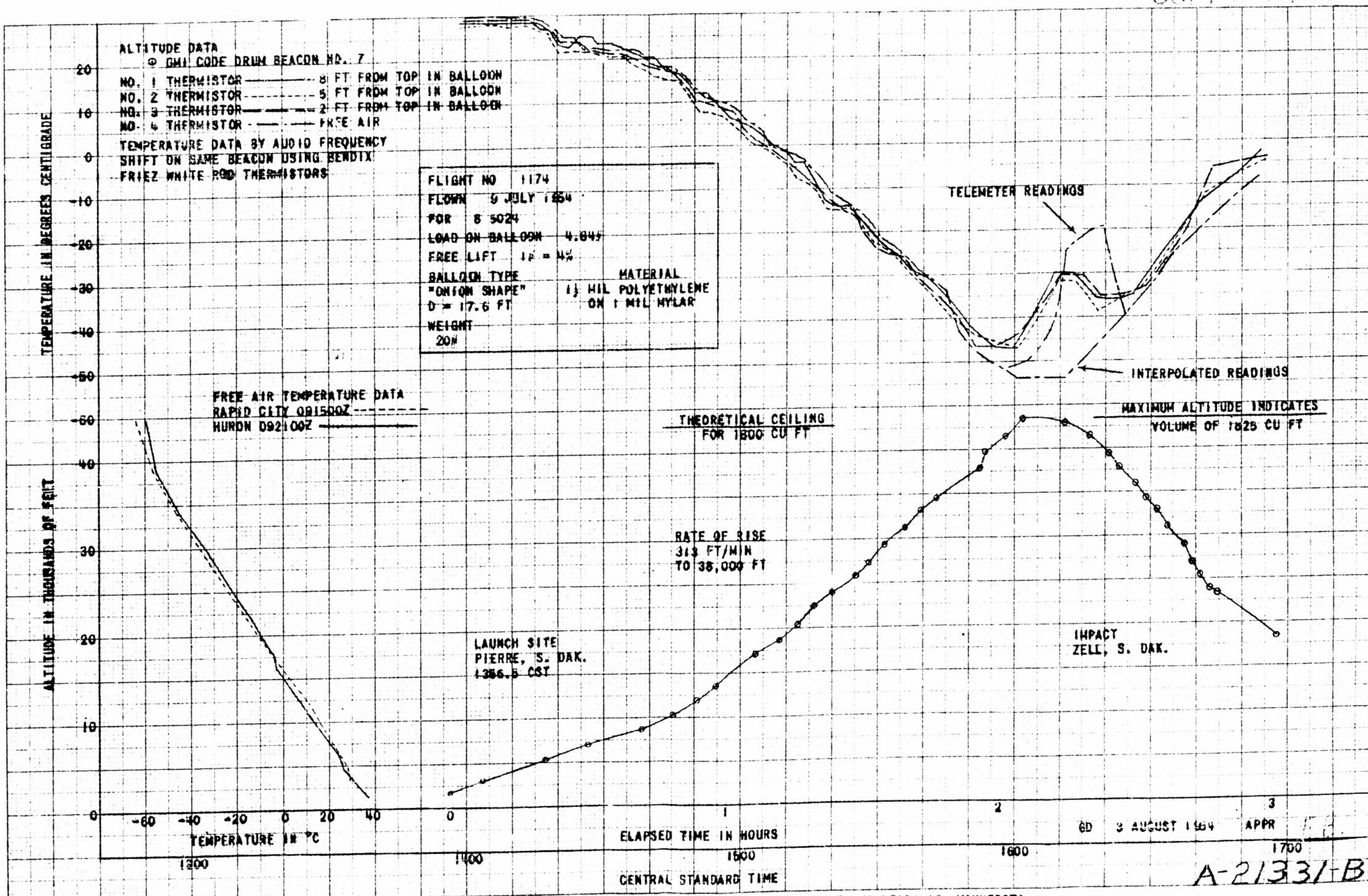

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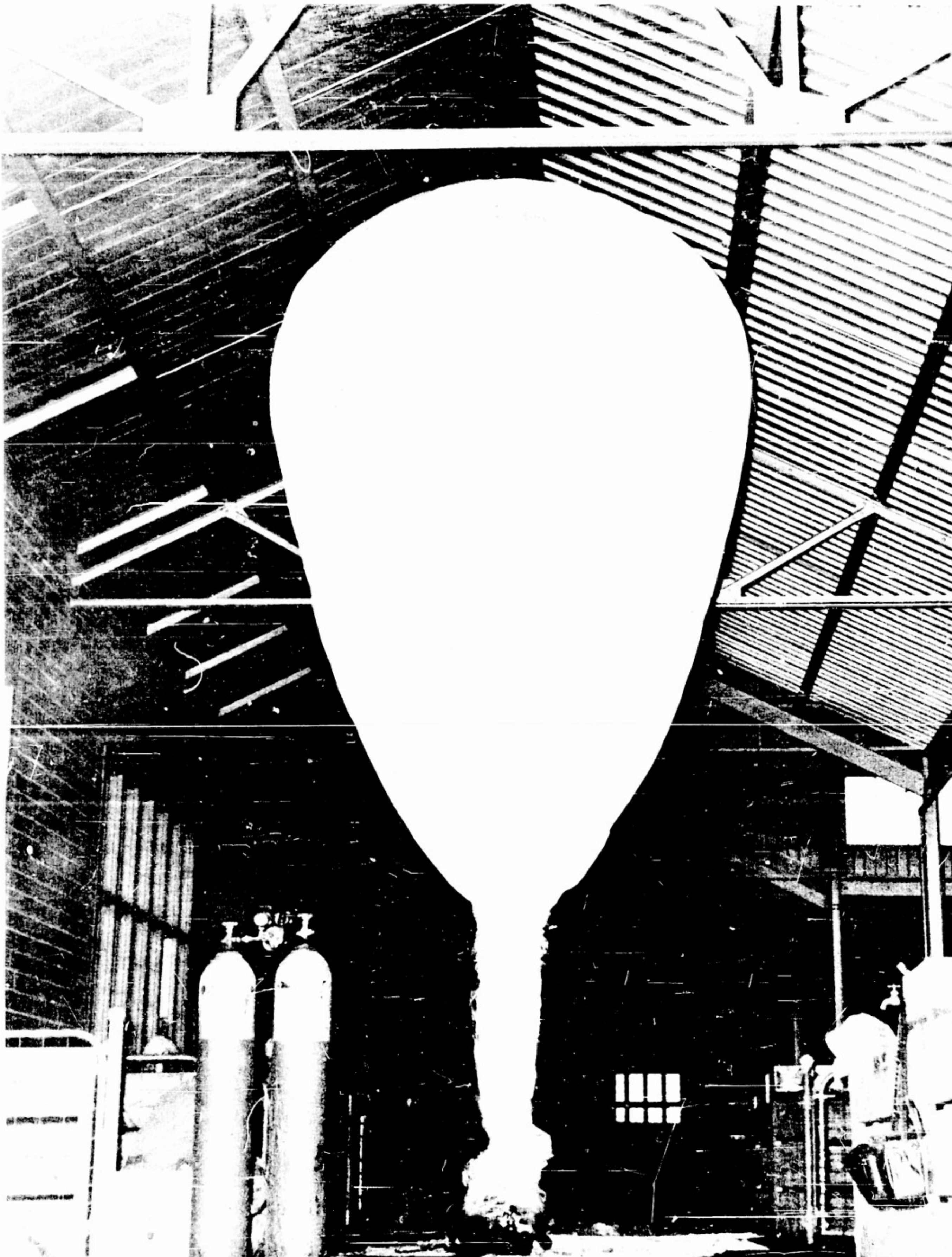

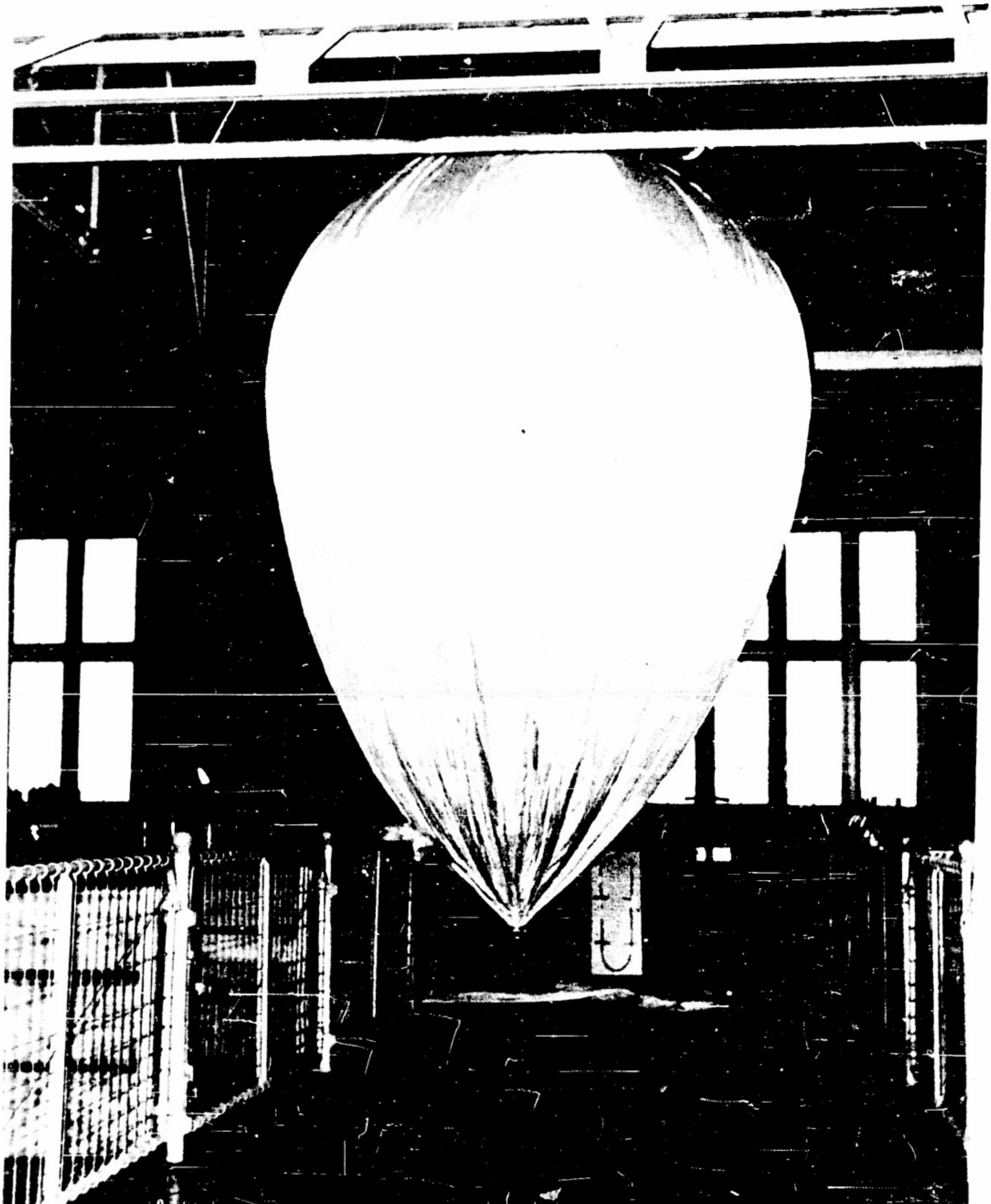

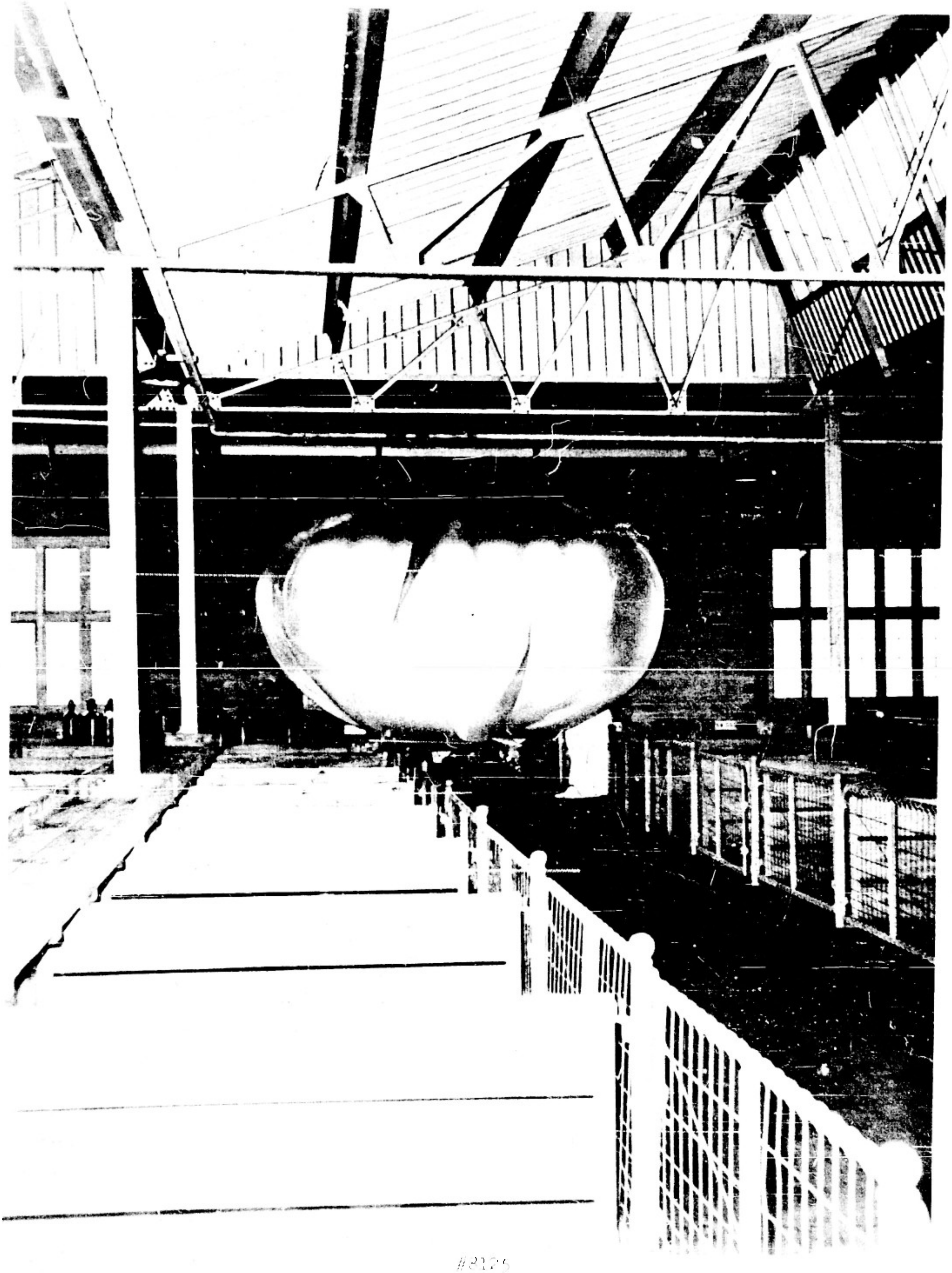

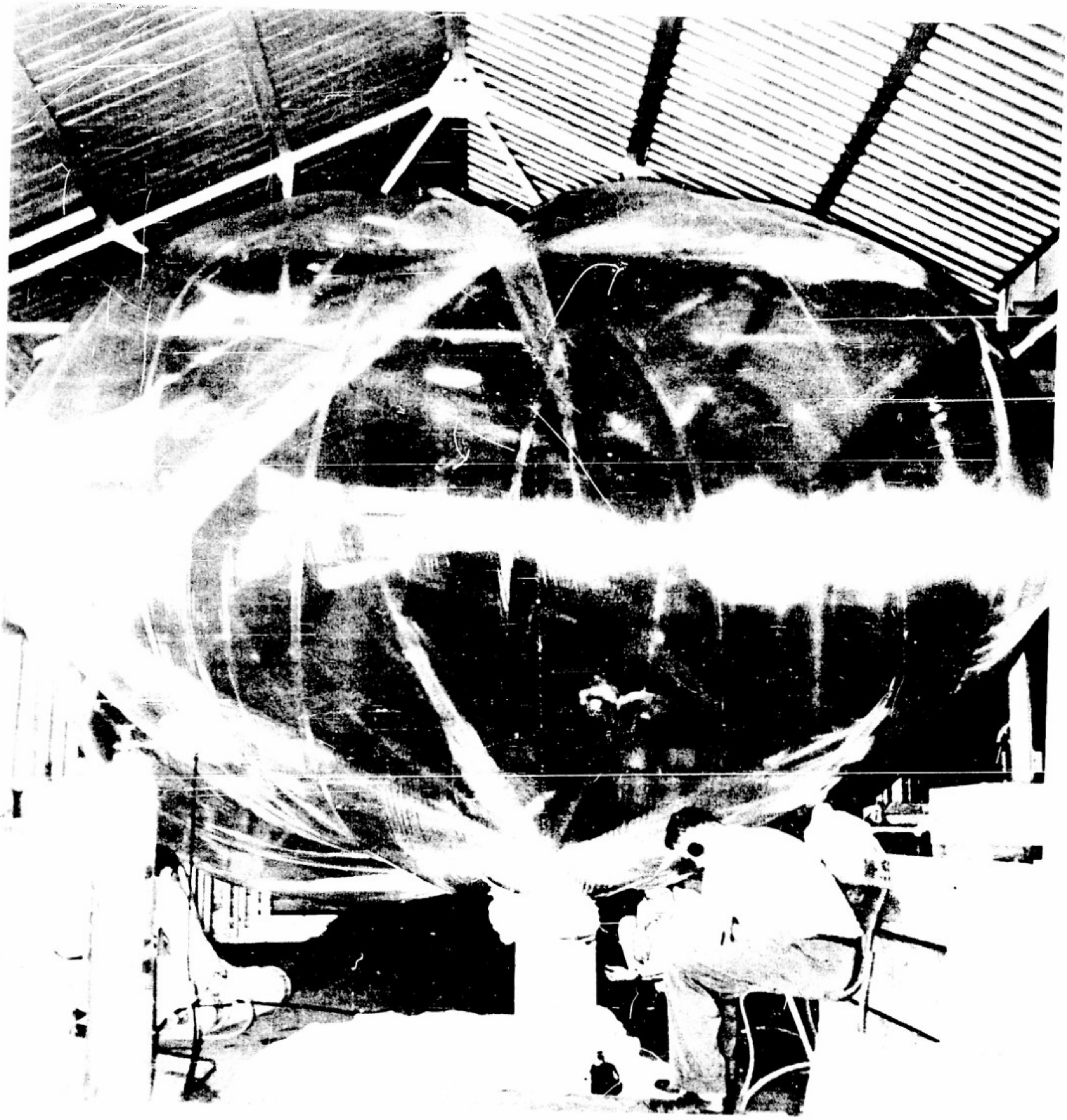

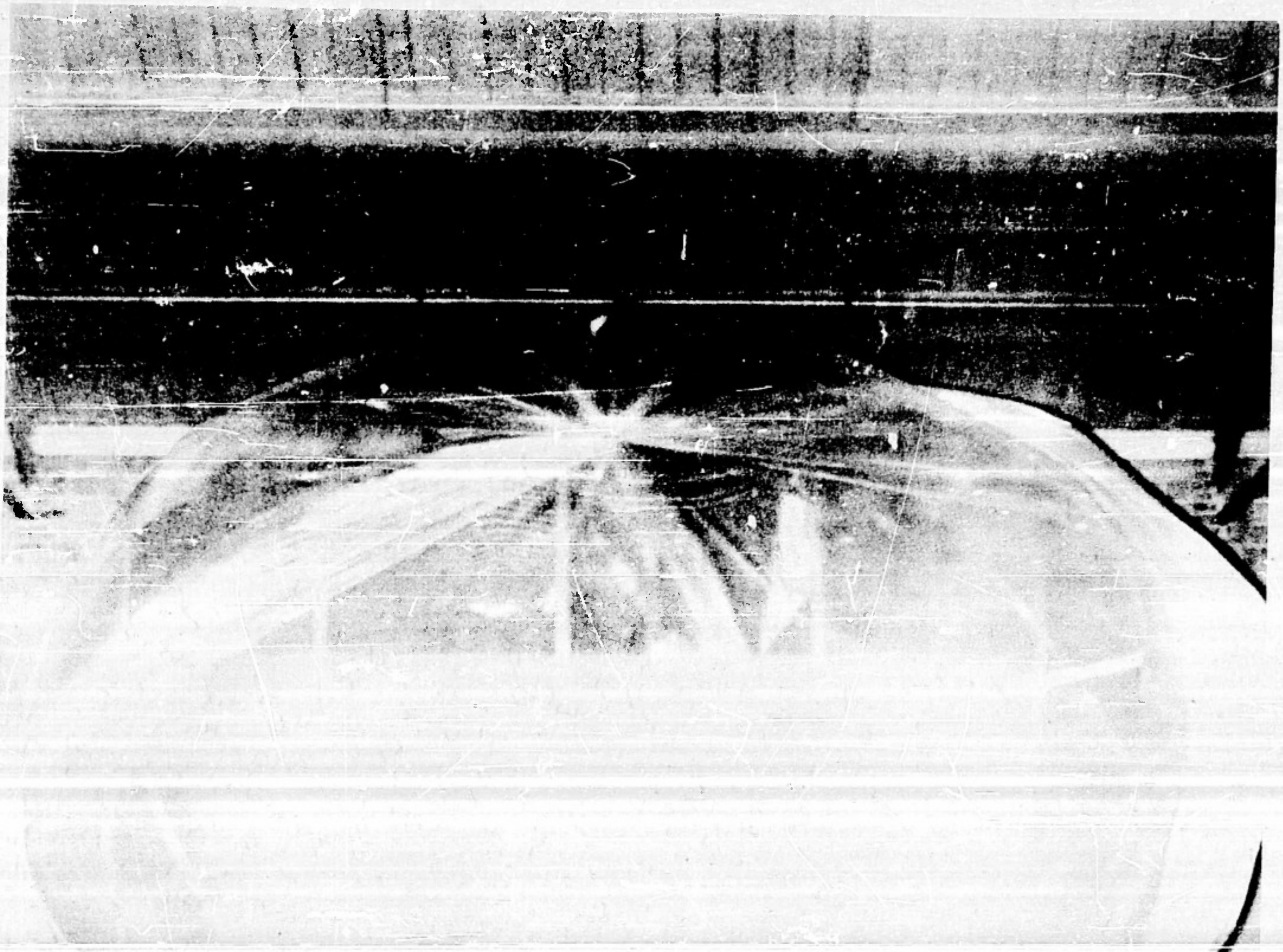

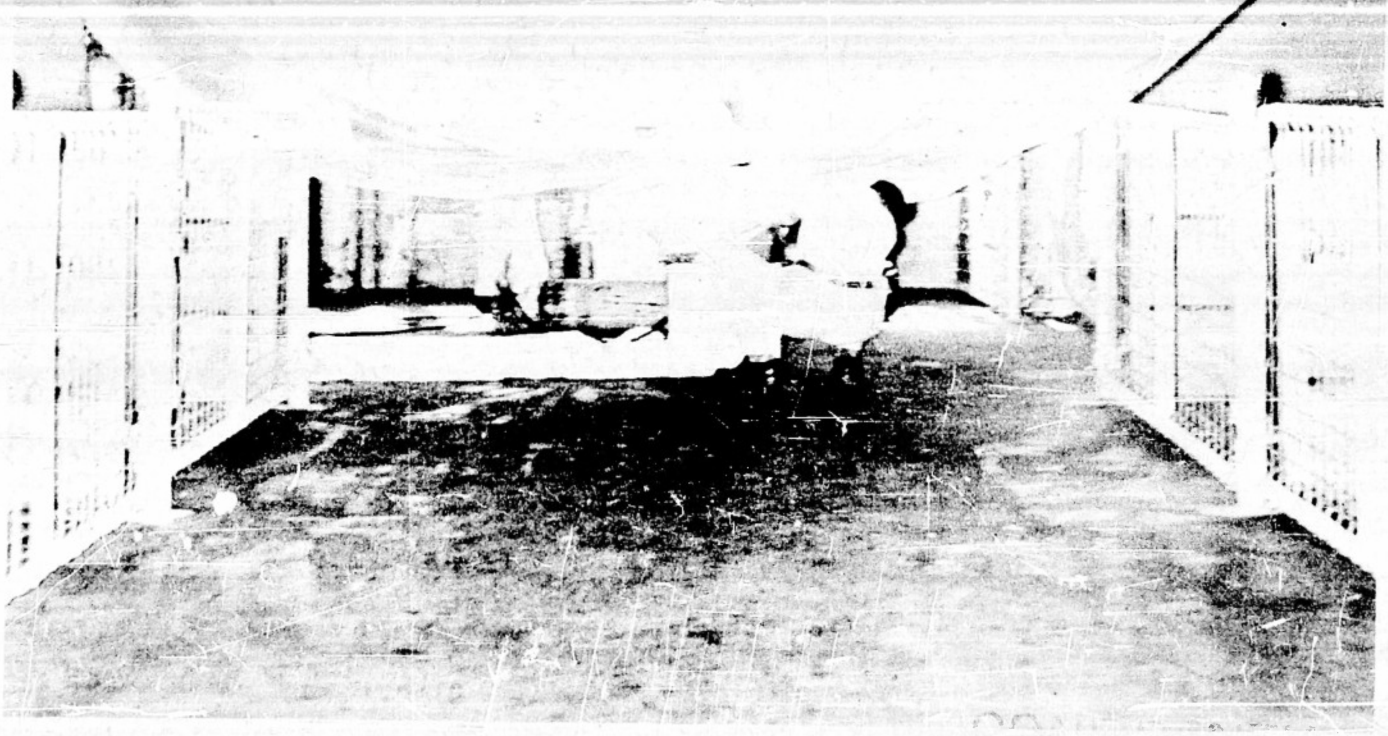

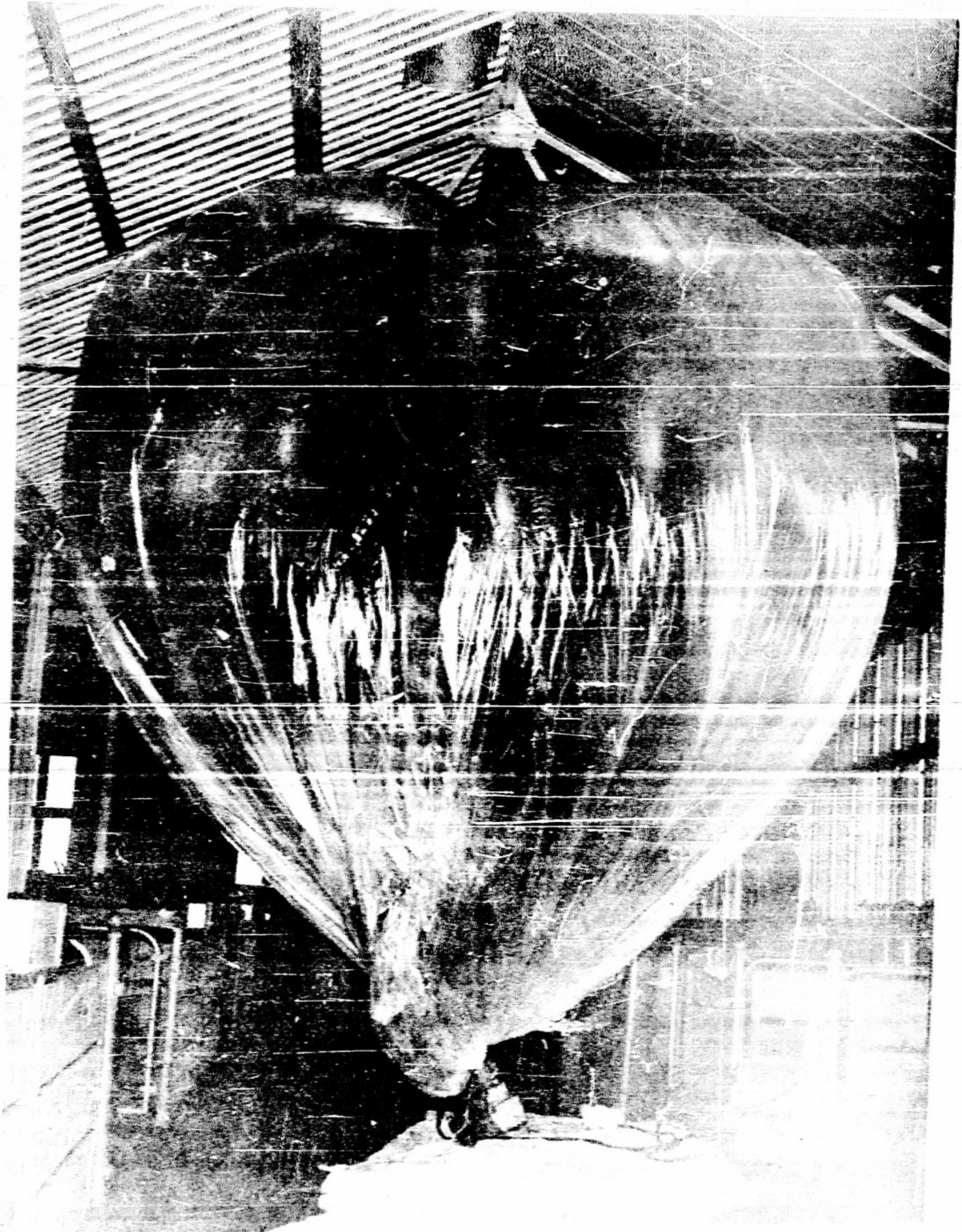

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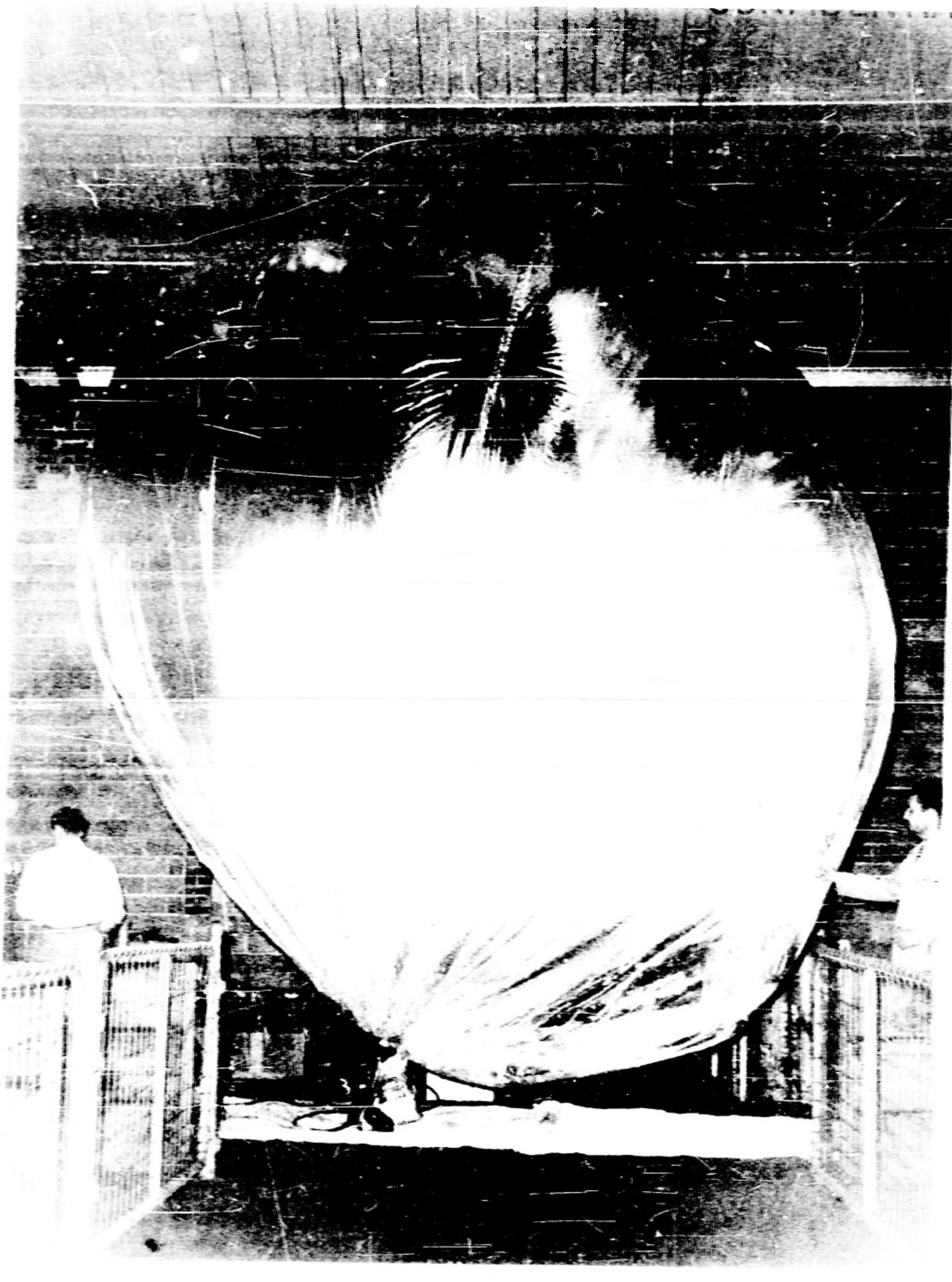

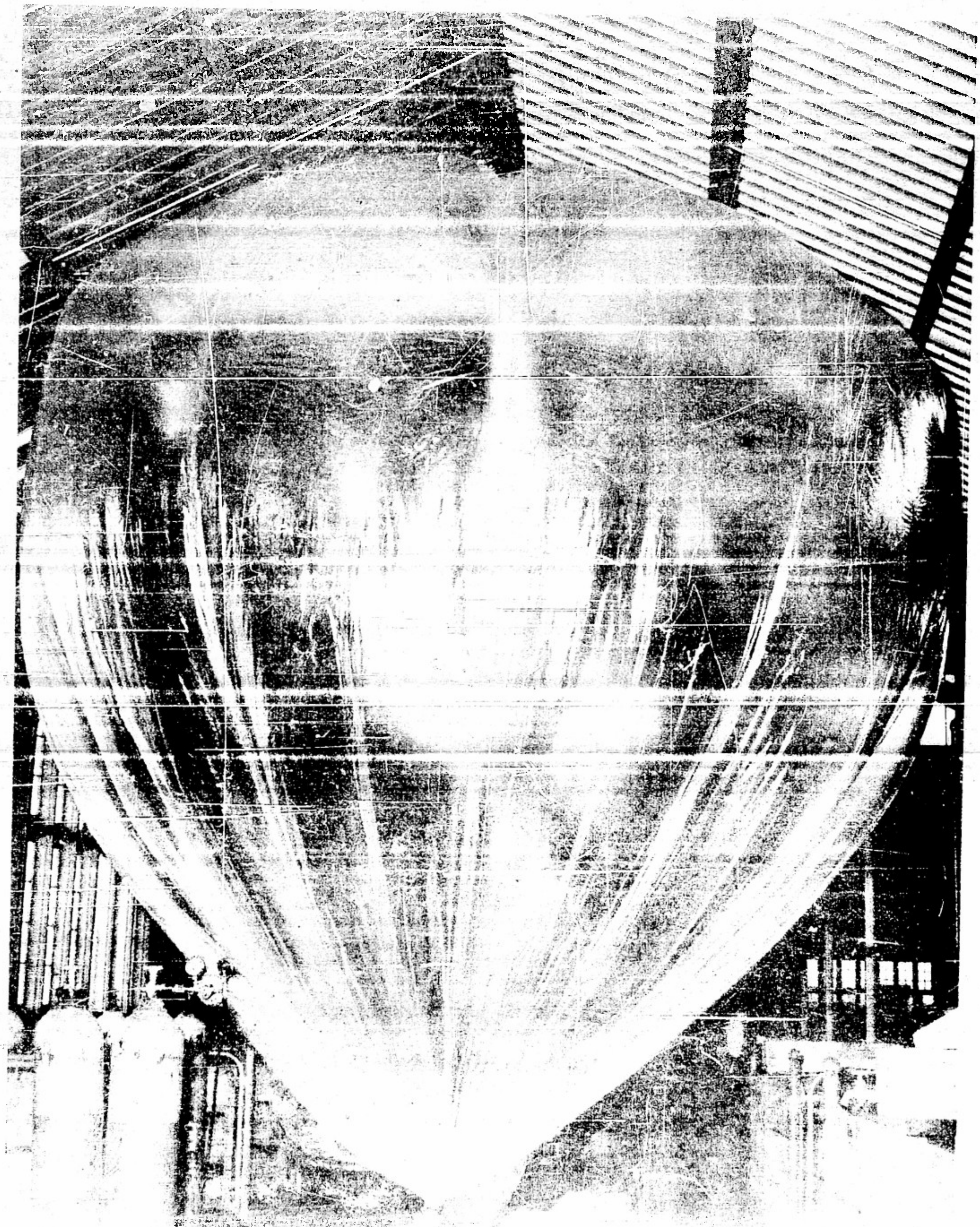

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